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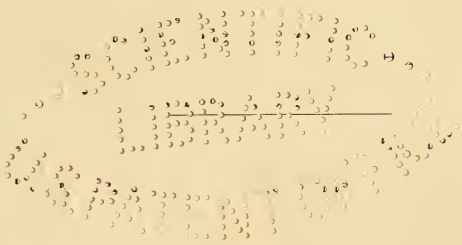

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Some years ago there was noted in this magazine the fact that the electrical industry had "come of age" and that twenty-one years had elapsed since the immense development of electrical engineering may be said to have begun. The inevitable sequence, the passing away of the men to whom this great industry owes much of its growth, is beginning to appear, and we publish in this issue the portrait of Mr. George W. Hebard, who died in New York in November last.

Mr. Hebard was born in Barre Centre, New York, in 1845, and prior to entering the electrical business was engaged in the manufacture of ammunition for small arms, a connection which is recalled by the fact that he was the executor of the Marcellus Hartley estate, which owned the Union Metallic Company and the Remington Arms Company.

His connection with the electrical industry appeared early in that development, as he became president of the United States Electric Lighting Company in 1882. He also took an active part in the early introduction of electric lighting in New York City, being a director of the United States Illuminating Company, aiding in the equipment of Brooklyn Bridge with the Weston system, parts of which are still in service. Later, as president of the United Electric Light & Power Company, he was closely affiliated with the introduction of the Westinghouse alternating-current system in New York City by the overhead system, and in its change later on to an underground distribution system, and the improvement of the system of distribution from the standpoint of the manufacturers. At the time the United States Company was taken over by the Westinghouse Company Mr. Hebard was the president of the former concern, and in the subsequent reorganization he was made vice-president of the Westinghouse Company. When, in 1888, the Westinghouse Company took over the Sawyer-Man Company, Mr. Hebard was given charge of the newly-acquired organization. At the time of his death he was acting vice-president of the Westinghouse Electric & Manufacturing Company.

GEORGE W. HEBARD

See reverse side.

CASSIER'S MAGAZINE

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THE FACTS ABOUT GOLD, SILVER AND IODINE IN SEA WATER

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By Henry S. Blackmore

THE subject of gold in sea water and its possible extraction having recently been again brought forward, or introduced to the public, by a paper read before the American Chemical Society at a recent meeting of the New York Section, it may not be out of place to refer to some data collected by the writer some years ago, during which time some four thousand three hundred and sixty-one dollars ($4,361) was expended by him in corroborating the data here presented, and which resulted in securing some two dollars ($2) in gold from the waters of Long Island Sound off New Rochelle, N. Y., and some ten dollars ($10) in gold from the mud of Eastchester creek near Pelham Bay, New York, there being about three thousand nine hundred and eighty-two dollars ($3,982) expended on the sea water investigation and three hundred and seventy-nine dollars ($379) on the mud.

In order to gain some conception of the value of the gold, silver, and iodine in sea water the following computation has been made, based upon analyses published by the various chemists who have made a study of sea water.

The calculations are based upon the following table of weights and measures:

1 ton equals 2,240 pounds.

1 pound (troy) equals 12 ounces, or 5,760 grains.

1 ounce (troy) equals 480 grains.

1 pound (avoirdupois) equals 16 ounces, or 7,000 grains.

1 ounce (avoirdupois) equals 437.5 grains.

1 ton, 2,240 pounds, 35,840 ounces, 15,680,000 grains.

1 cubic foot of sea water at 60 degrees F., 1.027 specific gravity, weighs 64.18 pounds.

35 cubic feet of sea water, 1 ton, or 2,246.30 pounds.

5,280 linear feet equals 1 linear mile.

147,197,952,000 cubic feet equals 1 cubic mile.

1 cubic mile of sea water weighs 4,205,655,771 tons.

Let us suppose it possible to precipitate from sea water the elements held in it, in solution or combination, by means of a process both rapid and economical. For example, if there could be found an insoluble substance having weight enough to cause it to settle rapidly and at the same time possessing the property of forming, with gold, silver, and iodine, an insoluble compound, it might be possible, by means of tanks so arranged that they would be automatically filled at each high tide and emptied at each low tide to com-

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mingle the insoluble reagent with the sea water, giving it time to enter into combination with the elements present and to be precipitated between high and low tide. If this could be done, the tanks might be filled and emptied twice every twenty-four hours.

Provided the insoluble precipitate containing in combination the gold, silver, and iodine could be made to give up the combined element without great difficulty and without great expense, and provided, furthermore, that the insoluble reagent employed to throw down the elements was of itself inexpensive and could in the process of freezing from it the combined elements be recovered and again used, it might be found practicable to carry out such a process on an extensive scale, and thereby secure a portion of the fabulous amount of gold, silver, and iodine contained in the three hundred million (300,000,000) cubic miles of the ocean.

Referring to the foregoing table of weights and measures, we see that one cubic mile of sea water contains, in round numbers, 147,197,952,000 cubic feet.

Taking as a unit a rectangular tank having a measurement of five hundred (500) feet long by five hundred (500) feet wide by five (5) feet deep (500′, 500′, 5′), and with a capacity of something over one million cubic feet, we will see that it would require two hundred (200) such tanks, filled and emptied twice each day, to allow of the treatment of one cubic mile of sea water in one year.

Twenty (20) such tanks would serve for handling one cubic mile of water in ten years; or, in other words, by means of twenty (20) such tanks one-tenth (1/10) of a cubic mile of water could be treated in one year.

Assuming that twenty (20) tanks of the size named could be built and operated for a year, we will calculate separately the amounts of gold, silver and iodine that might be secured by such process as we have indicated.

GOLD IN SEA WATER

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According to the estimates furnished by the authorities cited above, each ton (35 cubic feet) of sea water contains from one-half to one grain of gold. This amounts to from 134 to 268 tons per cubic mile.

Taking the minimum amount, 134 tons, as a basis, and allowing that our twenty tanks would permit of the treatment of one-tenth of a cubic mile in one year, we have, in round numbers, 13 tons, or 465,920 ounces of gold.

The average market price of gold we may say to be $240 per pound, or $20 per ounce; this would represent as the result of one year's work the sum of nine million three hun-

dred and eighteen thousand four hundred dollars ($9,318,400).

Sonstadt, in the *Chemical News,* before noted, states that he employed the following test in determining the presence of gold in sea water:

"Two or three decigrammes of pure ferrous sulphate are dissolved in the water, which is acidulated by two or three drops of hydrochloric acid. The solution is heated in a chemically clean, well glazed porcelain dish over a small flame, so managed that the flame may touch the under part of the dish without causing ebullition. Under these circumstances a lustrous film of iron oxide forms in the dish, commencing from the portion directly heated by the flame. The heat is continued, without boiling, until the sea water is evaporated to about half, or so long as the film increases in extent and in lustre. The liquid is then poured off, the strongly adherent film is rinsed with a little water, and then about 50 cc. of strong chlorine water is allowed to stand in the dish for an hour or two, after which it is slowly evaporated down (over the film) to a few drops, a drop of dilute hydrochloric acid being added towards the end of the evaporation. The liquid, which should be nearly colourless, is then poured into a test-glass containing a few drops of solution of stannous chloride, when, after a few minutes, the liquid takes a bluish or purplish tint, which may be exactly matched by a drop or two of a suitably diluted solution of gold added to a corresponding portion of tin-salt in another glass."

Prof. A. Liversidge, F.R.S., of the Chair of Chemistry, University of Sydney, New South Wales, in his paper read before the Royal Society of New South Wales November 6, 1895, relative to the amount of gold and silver in sea water, says:

"The sea water first examined was collected from the coast at Coogee, away from any fresh water or other drainage. Eleven trials of this water were made with 200 cc., as recommended by Sonstadt, but no trace of a purple or even pink tint was obtained; but with 600 cc. a faint amethyst tint was obtained after standing some time. As a rule, after adding the stannous chloride a white or gray precipitate came down in the course of a few days, and this precipitate in many cases became pink, purple or slate coloured.

"To check Sonstadt's method, various experiments were carried out. Gold chloride (from pure metal dissolved in chlorine water) was added to Coogee sea water in the proportion of one grain of gold to the ton, and 200 cc. of this was treated by Sonstadt's process on March 19, 1895, when a light brown precipitate was thrown down by the stannous chloride; on the 27th the precipitate was of a red colour below with a pale pink layer above; on the 3d of April the pink tint was more decided. Hence, if allowed to stand for a few days, the test will detect in 200 cc. the presence of added gold in the proportion of one grain to the ton of sea water, the gold originally present only being recognizable in 600 cc.

"On August 14, 1895, two more samples, each of two litres of Coogee water were tested. On the 15th the precipitates were brownish; the brownish tint seems to be due to the presence of gold. The contents of the two test tubes were mixed together, dried and scorified with 250 grains of assay lead free from gold, when a small bead of gold was obtained."

Prof. Henry Wurtz, in his memoir read before the American Association for the Advancement of Science at the Buffalo meeting, August 1, 1866, advanced the theory of a primeval ocean comprising a solution largely of sulphates and containing ferric-sulphate, which he claimed to have discovered to be a solvent for gold, and which was published serially in the *American Journal of Mining,* before noted, says:

"First. The contents of the primary metalliferous strata, as well as

the lodes therein contained (both ore and gangue), were deposited from suspension and solution in the hot waters of the primeval ocean.

"Second. These waters contained in solution all the metals, in forms soluble, if not in pure water, yet in solution of some one or other of the saline constituents of the ocean.

"Third. The metals now found in these rocks as sulphides must have existed in the waters of that ancient ocean as sulphates, or certainly associated with enough of the sulphates of other bases (alkalic and earthy) to furnish the sulphur now extant in the sulphides.

"Fourth. Through some great and all-pervading reducing agency, doubtless that of carbon of dead organisms—which had lived probably to some extent even in the concentrated brines of the ocean, but chiefly in cooler and more dilute waters along and near its coasts, formed by the influx of continual torrents proceeding from a constant, universal and enormous condensation upon the mountain heights and slopes—the metallic sulphates became sulphides, and were as such deposited in admixture with the sediments and precipitates (whether mechanical or crystalline, or both) of the oceanic waters.

"Fifth. The carbon doing this work passes back in the act into the atmosphere as carbonic acid, to be again taken up by vegetable organisms; or, by condensing as aqueous solution on the mountain slopes, to be converted into calcic bicarbonate by contact with calciferous silicates, and flow back in this form to the ocean, to be there itself converted, sooner or later, into sediments by both chemical and vital influences; thus the carbon performing alternately its several allotted functions till finally locked up in the forms of calcite, dolomite, chalybite, graphites, coal, petroleum, asphalts and other resinoid substances.

"Sixth. The oceanic gold was at the same time reduced to the metallic form, and its nascent crystallizing molecules arranged themselves, for the most part, under the polarizing influence, or induction, of the immensely predominant mass of the crystallizing sulphides, isomorphously (or rather homœomorphously) with the latter into (what we call) crystallic or polaric homogeneity.

"Moreover, it is possible that a very important share of the primeval oceanic gold may still be held in solution. If we suppose the total probable amount of gold yet eliminated from the earth by human toil to be diffused throughout the present ocean, it would, without doubt, be enormously beyond the limits of our present (it must be admitted, not very delicate) modes of chemical detection.

"A few simple calculations, to illustrate this, may be interesting. We shall be within probable limits in assuming the average depth of the 150,000,000 square miles of the present ocean to be at least two miles. Then taking the density as one-fortieth more than unity, the total weight of our ocean is, in round numbers, over 1,400,000,000,000,000,000 tons. Now as we estimate the gold in human hands, at the date of the California discovery, at as much as $2,000,000,000, and the annual average during the eighteen years since then at $170,000,000, we have a sum total of about five thousand million dollars, which would be in the proportion of one dollar's worth of gold in every two hundred and eighty million tons of water. This is less than the one hundred and sixty-two million millionth part of weight. Now, as it is well known that $1 in gold per ton of material is about the limit of the most delicate means of certain detection of this metal yet known to us, it follows also that, so far as ordinary chemical analysis has as yet indicated, the present ocean may contain more than two hundred and fifty million times more gold than the total present wealth of mankind in this metal, this amounting

to about $1,250,000,000,000,000,000.

"In this connection I would recall the celebrated discovery of silver in the ocean water by Malaguti, since confirmed by many others, and would urge that gold be also sought for with renewed precautions. It may be that if we had for the latter tests as delicate and characteristic as for the former it would have been already detected."

The available recovery of gold from sea water at present, judging from all the practical data we have at hand, is one-fourth (¼) of a grain per ton, which is equivalent to about one cent. However, by use of a chemical sponge absorbing it from great volumes of sea water, brought in contact with it at each tide, a steady, gradual and continued accumulation may result until the material or residue containing the gold precipitate is rich enough in gold collected to pay for its isolation, separation and recovery.

The beautiful and vari-colored marine vegetation and corals of the tropics contain coloring matter produced by the precipitation or deposition of gold and silver from the sea water by the action of organic deoxidizing or reducing agents, together with the sunlight shining through the crystal water, which produces the beautiful silver-gold toning effects.

SILVER IN SEA WATER

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(B) "The Removal of Silver and Gold from Sea Water" by Muntz metal sheathing, ibid., l. c.

According to Malaguti and other chemists, every cubic mile of sea water contains 536 tons of silver, two grains to the ton.

Allowing that one-tenth of a cubic mile could be treated in one year by means of the twenty tanks described, we would have a product of fifty-three and six-tenths (53.6) tons, or 1,921,024 ounces.

Placing the average market price of silver at 45 cents an ounce, we have, as a result for the year's work, silver to the value of eight hundred and sixty-four thousand four hundred and sixty dollars ($864,460).

IODINE IN SEA WATER

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Sonstadt, *Chemical News,* Vol. XXV., pages 196, 231 and 241. An abstract of this article occurs in *Watts' Dictionary of Chemistry,* Vol. VII., page 670.

The same cubic mile of sea water containing the 134 tons of gold and the 536 tons of silver contains, according to Sonstadt and others, the enormous amount of eleven thousand and seventy-two (11,072) tons of iodine, or about 42 grains per ton of sea water.

Taking $2.50 per pound as the average market price of iodine and allowing for the product of 20 tanks for one year (1,107.2 tons), we have a yearly output of iodine of the value of six million two hundred thousand three hundred and twenty dollars ($6,200,320). As to the demand for iodine, it may be noted that there was imported into the United States alone during the fiscal year of 1910 an amount equal to 609,482 pounds.

To sum up. On the basis of twenty (20) tanks of a capacity of

about one million gallons each, filling and emptying automatically each high and low tide, together with a reagent of the nature indicated, to treat chemically each year one-tenth of a cubic mile of sea water and to remove therefrom the contained gold, silver, and iodine at the market price for these, we would have, as the value of one year's output, gold, $9,318,400; silver, $864,460; iodine, $6,200,320, or a grand total of $16,383,180; or, ignoring the value of iodine, $10,182,860.

It has been ascertained and determined by the highest authorities that gold occurs and exists in sea water approximating one grain to the ton and silver two grains to the ton in practically uniform proportions and percentages by analyses of sea water obtained from all parts of the globe.

The solvent action of the sea water for gold and silver seems to be limited to approximately one grain of the former to two of the latter per ton of water, and, when depleted of the metal by deposition or separation, it is free to take up a similar amount of these metals from whatsoever source it was originally derived, so that the water would be continuously and constantly replenished or enriched if processes should be devised or put in use for the practical separation of them on any commercial basis.

The gold and silver seem to be held in solution in the sea water by the iodates and iodides of the alkali and alkali-earth metals, sodium, potassium, magnesium and calcium, and particularly by the iodates, which, when reduced by deoxidation to iodides, tend to precipitate the gold and silver present.

This precipitation is gradually going on in the creeks and inlets of salt or sea water, where such reducing agents as accompany sewage are constantly commingling, and the mud which communicates with such bodies is gradually becoming enriched with such precipitates, until a time may be reached when a practical or profitable cyaniding extraction of the gold may be accomplished.

The chemical precipitation, or separation of gold, silver and iodine, however, may be regarded as an accomplished fact, regardless of the fact that these elements are present in an extremely minute or diluted form. The whole question of the recovery of the precipitate profitably is purely an engineering problem, and depends upon the conditions that the precipitate shall not be lost by suspension in the circulating currents of associated water, and that the apparatus be so designed that large volumes of sea water may be handled and chemically treated through the agencies of tides or other means economically, without the necessity of artificially generated, supplied or applied power.

Provided the data here presented in reference to gold, silver, and iodine in sea water be correct and the estimated results not overdrawn, it would seem worth while to devise a mechanical means, based upon proper engineering lines, for handling large bodies or volumes of sea water economically, and to make an experiment on a scale commensurate with the magnitude of the values involved, which may result in the demonstration of a process of incalculable utility, or, at any rate, from a scientific standpoint, determine, once for all, the possibilities of ever obtaining any practical results of commercial value based on these lines.

The fact that fraudulent representations as to the practical separation and recovery of gold on a commercial basis were made several years ago, and that the scheme was the subject for swindling people out of money by unscrupulous individuals, is no excuse for scientists or the people in general ignoring the fact that gold exists in sea water or scoffing at legitimate research looking toward the discovery of means or methods whereby its eventual practical securing may be accomplished or may result.

THE CONDENSATION OF STEAM

MODERN APPARATUS AND METHODS

By Theodore Rich

AT one time the question of the selection of a suitable type of condenser to work in connection with steam power plant was a comparatively simple matter; choice was in most cases limited to two simple types, the jet and the surface. The design was decided largely by rule of thumb, the actual arrangement of a condensing plant being usually looked upon as a matter requiring little study or attention.

During the last twenty years there has been a great change, one great factor being the requirements of the electric power station. In the early days of electric power transmission it was considered that the doom of the small independent plant, whether for the direct driving of machinery or for the supply of electric light or power, was a matter of only a few years; but it was quickly found out, to the disaster of many power company shareholders, that unless the generating plant was arranged to give the utmost all-round economy, with all the apparently insignificant details well thought out, the capital cost of the transmission and distribution systems and the electrical losses, which even in these days are still very much in evidence, would quickly neutralize any increase in economy due to the use of large units.

It may be said that up to comparatively few years ago, condenser practice made very little advance since the days of Watt, and it must not be denied that owing to the large cylinder volume used many of the old Cornish engines were able to utilize the available vacuum to a remarkable extent, and results were obtained seventy or eighty years ago which even to-day are not easily beaten. At one time practically all steam engines were of the slow-speed type, the condenser was placed at the back or underneath the cylinders, the air pumps being either built in line or placed in a pit and driven by means of cranks and rods.

There are several factors which have influenced the development of the modern types of condensing plant. The high-speed enclosed engine, which came into general use for electric driving in the early nineties, did not lend itself to the direct driving of air pumps, and this had a great deal to do with the development of the independent condensing plant, or what should be more correctly termed the independently driven condensing plant.

The greatest development has taken place, however, since the rise of the steam turbine as a power unit. Constructional features in connection with piston and port areas tend to prevent the economical use of high vacuum in the steam engine, although some more or less successful attempts in connection with marine engines and uniflow steam engines have been made lately, but the steam turbine can become a serious competitor under most conditions only when the vacuum is 26 inches and upwards. The steam turbine is essentially a condensing machine, and though absurd claims are sometimes made by those who advocate turbines for all classes of work, except under very special conditions, they are not suitable for working under moderate vacuum, non-condensing, or with a back pressure; and under no circumstances

can they compete with the steam engine in actual economy under these latter conditions.

At one time the use of a condenser was looked upon as being almost out of the question unless the steam plant was arranged alongside a river or canal, or in a district where large cooling ponds could be arranged. The advent and development of artificial water-cooling appliances, such as cooling towers and sprayers, the development of which may be said to have taken place largely on the Continent of Europe, have changed all this, and it may be said that, speaking generally, where there is room for a power station there is room for the necessary cooling apparatus. It cannot be said that this fact has always been realized, even in recent years, and many big power stations have been put up miles away from the economic centre of distribution, and enormous capital cost involved in transmission and transformation plant, with corresponding power losses, for the sake of obtaining cold water for condensing and an extra inch or so of vacuum. One factor which kept back the development of condensing appliances was that electric generating stations were for many years almost wholly restricted to a lighting load, so that the period of full load in the twenty-four hours was comparatively short; that is to say, the load factor was bad, and the extra economy for a few hours each day, and that perhaps only in the winter, did not compensate for the extra capital cost and upkeep. For some years the best records for power station economy were held by non-condensing stations. Nowadays in most industrial districts the power load is becoming the predominating factor; and as the power load is in most industries a comparatively long-hour load, and the margin of profit in power supply is exceedingly small, a fact that some power companies and municipalities have found to their cost, the question of economical condensing becomes of great importance. The commercial introduction of the exhaust turbine, due very largely to the work of Professor Rateau, has given further impetus to condenser design, as these machines can only prove an economic success under conditions of high vacuum.

The problem before the designer of a modern power station with regard to condensing is an exceedingly complex one. In some quarters a condenser is still looked upon as only an auxiliary, but to-day it is as important a factor as the boiler, the steam engine, turbine, or the electric generator. These latter, however, have now settled down to one or two standard types differing only in detail, and with very slight differences in actual working results, despite the somewhat startling claims sometimes made by makers of particular apparatus, while there are still very large differences in types and designs of condensing plant. It may almost be said that the correct choice of this has more influence on central station economy than that of the boiler and generating plant put together. The correct choice may be said to depend on a number of apparently insignificant factors, among which might be mentioned quality and cost of feed water; source, quantity and temperature of circulating water; and the cost of power to drive condenser auxiliaries; the question of load factor is also of importance. In densely populated districts, where cooling towers or other artificial cooling arrangements have to be made, questions regarding the humidity of the atmosphere and possibilities of difficulties from actions for nuisance or obstruction of light have to be considered. It must not be forgotten that the condensation problem must be considered as a whole—that is to say, the condenser proper, the air pump, the circulating plant and pipes, and the artificial cooling arrangements, where required, must be considered together before an economical result can be realized.

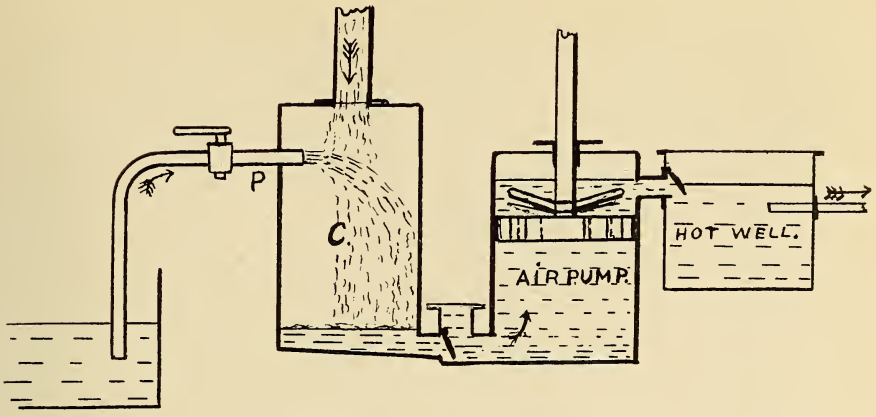

FIG. 1.—SIMPLE JET CONDENSER

It is impossible to lay down the law and say that any one type or maker is better than the others; there are so many types and so many factors that what may prove suitable for one combination of circumstances may prove to be quite out of place in another. It might be pointed out that there are fashions in engineering plant as well as in most other things, and occasionally, as the result of a passing craze, types of condensers are installed in most unsuitable positions, with the result that the type in question gets quite undeservedly a bad name.

It is or should be the object of the designer of an installation to obtain the highest possible vacuum consistent with the inlet circulating water temperature, with the minimum power to drive the auxiliaries and the highest possible hot-well temperature at a minimum capital cost and cost of upkeep. It is at times difficult to adjust these factors, but the economic limits are quickly reached, and though with exhaust turbines a very high vacuum is often commercially practicable, except for the honour and glory of making some record steam consumption tests, high vacuum is of no use in itself if the cost of getting it is excessive. The hotter the temperature of the incoming circulating water the lower the practical vacuum limit; and as hot-water circulation usually implies the use of artificial water-cooling plant, which in its turn requires a considerable head against the circulating pumps, with a large volume of water, the commercial limits of vacuum in such cases are not very high. With a high-pressure steam turbine from 26 inches upwards the economy may be said to vary roughly 5 per cent per inch, though with the exhaust turbine, as would be expected, the rise in economy is greater than this, especially at the higher limits, but when working close to the barometer the extra power required by the circulating pumps rapidly neutralizes the increased steam economy. The temperature of the hot-well is also an important item, as the higher the vacuum the lower the temperature of the feed water.

The design and arrangement of condensing plant are a matter of compromise, and a number of conflicting factors have to be considered. In connection with condensing plant generally, makers are often called upon to quote and submit proposals and sometimes to agree to stringent guarantees on very limited information. In plant of this character it is the little things that count, and information on which to base proposals can hardly be too detailed. Competition in the condensing plant branch of engineering is of a very keen char-

acter, and there is sometimes a feeling, as in other clases of work, that those who give the best guarantees must necessarily supply the most suitable plant, as there is a tendency in view of the number of variable factors to exaggerate the results obtainable or to leave an insufficient working margin.

Taking all classes of condensers, despite the fact that the variations in construction are very large, two main classes are still to be found:

Jet condensers, where the water condensed mixes with the circulating of injection water.

Surface condensers, where the water condensed does not mix with the circulating water.

These two groups may be divided into a number of sub-groups, but the principle and a number of the properties pass among the different members of the group.

Taking the two main classes, the features may be summarized as follows, though it must be understood that recent design has to a large extent modified some of the inherent disadvantages of both general types.

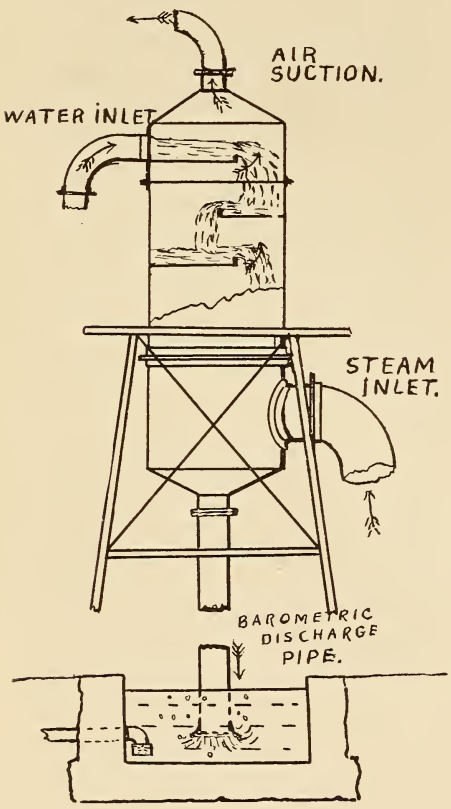

FIG. 2.—BAROMETRIC CONDENSER

JET OR MIXED TYPE	SURFACE OR UNMIXED TYPE
Simplicity with a minimum number of parts requiring adjustment or cleaning.	This type requires periodical cleaning and where hard water is used for circulating, or where much oil is present in the condensed steam, the expense and inconvenience of this cleaning may become an important factor.
The mixture of steam and water, with the absence of heat transmission through metal walls, tends towards condenser efficiency.	
In practice this feature has little material influence.	
Owing to the mixture of the injection water with the hot-well supply, in cases of hard boiler feed or circulating water, the whole of the boiler feed has to be softened or treated.	As the hot-well water and circulating water do not mix, water quite unsuitable for boiler feed may be used without loss of heat units in condensed water, and where the feed water is hard, only the make up need be treated.
There is some tendency to instability, especially under very variable loads. Condensers of this type are usually very sensitive to air leakages.	
The use of mixed condensers makes accurate engine or turbine tests difficult.	
At first sight the jet plant would seem to be the cheapest in first cost, but this is modified by various factors and difference in price usually more apparent than real.	
In most cases with turbine plant heavy and expensive connecting pipes are required with bends leading to loss in vacuum.	In turbine work the surface condenser may be bolted up to the turbine exhaust without intermediate pipes.
Little fear of choking from dirty water where loss of hot feed does not matter.	Where exceedingly dirty river or estuary water is used, elaborate and expensive straining plant is necessary.

TYPES OF JET OR MIXED CONDENSER

Chamber jet, with wet air pumps.

Counter-current jet, with water and dry air pumps.

Barometric jet, without air pump.

Barometric counter-current, with dry air pumps.

Counter-current, with rotary air pump.

LeBlanc jet condenser.

Centrifugal jet condenser (roturbo type).

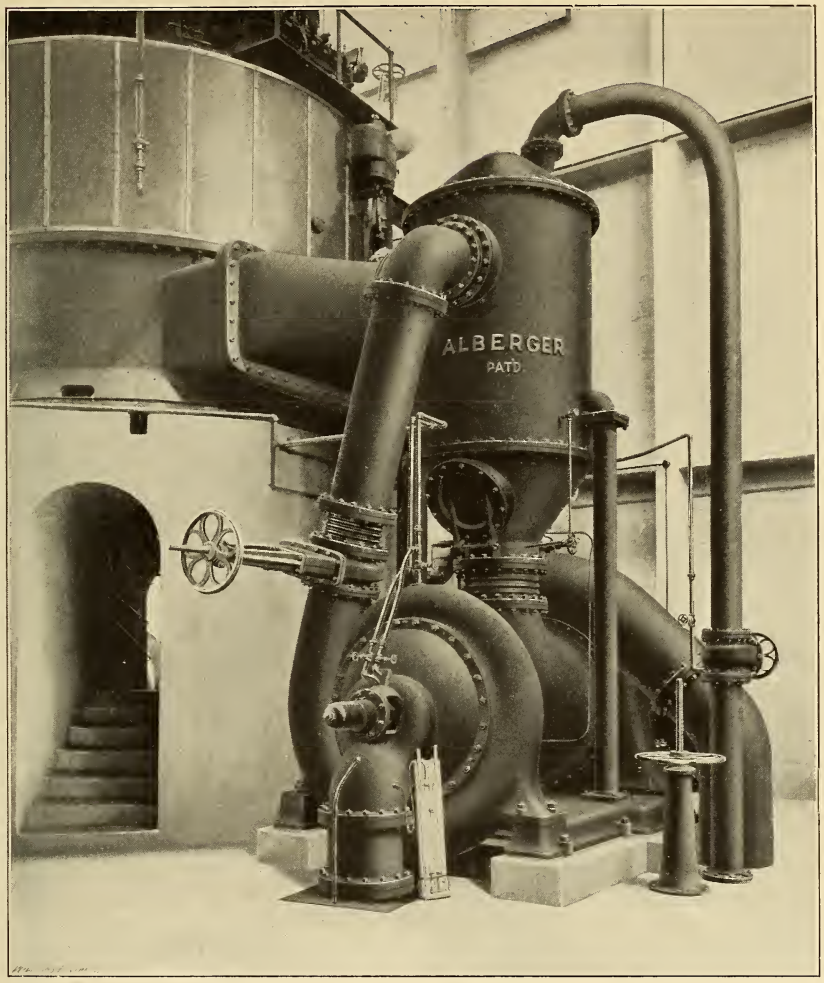

FIG. 3.—CENTRIFUGAL CONDENSER WITH PUMPS. ALBERGER TYPE

Ejector condenser working without head.

Ejector condenser working with head.

TYPES OF SURFACE CONDENSERS

Normal horizontal type, with circular and (or) rectangular section of shell, with wet air pump.

Counter-current condensers. Type with compartment drainage. (Contraflow, etc.)

Condensers with weirs and some drowned tubes (Allen and others).

Vertical type, open and closed top, for bad water (Weiss, Mirrlees and others).

Use of wet and dry air pumps.

Evaporative condensers (Ledward & Beckett, Deane & Beale, and others).

Internal evaporative (new American type).

Conductive surface (Fouché).

TYPES OF AIR PUMPS

Simple reciprocating air pumps with bucket and foot valves.

Edwards pumps with valveless pistons.

Simple and compound dry air pumps.

Rotary air pumps (LeBlanc and others).

Steam or steam and water-jet pumps working alone or in connection with rotary pumps.

TYPES OF CIRCULATING PUMPS

Circulating pumps.
Reciprocating.
Centrifugal.

METHODS OF DRIVING PUMPS

Driving by means of levers, rods or gearing from main engine.

Independent steam driving.

Electric drive.

In all classes of central station practice it is desirable, in order to economize coal, to pump the feed into the boiler as hot as possible, and though economizers may be used to this end, even in this case in order to prevent sweating of the tubes it is unwise to pass the water through too cold, therefore the use or not of the hot-well discharge is a matter of great importance. In the ideal case, where an unlimited supply of cold water of good quality is available, a jet condenser would, in most cases, prove satisfactory and economical in first cost and operation, though where a very high vacuum is required there are objections to jet condensers of the normal type. Where the circulating water is dirty, or contains salts, a surface condenser is advisable in most cases, in order that the amount chemically treated may be limited to the make up fee. Where the circulating water is distinctly acid in character, as with some pit waters, it is advisable to use some form of jet condenser, as the parts can be made much less liable to corrosion than condenser tubes and tube plates. In such cases cold, fresh water must be used for boiler feed, and under such circumstances it is usually advisable to use steam-driven auxiliaries and use the exhaust for feed-heating purposes.

The problem of condensation may seem, in a way, to be an engineering paradox. In the boiler house and engine room every effort is made to prevent the loss of heat; the boilers, pipes and engines are covered with non-conducting composition; but in the condensing plant every effort is made to get rid of the latent heat of the steam in the most efficient way.

It can easily be seen from the given lists of types of condensers and pumps that the selection of the right plant is by no means a simple matter.

It must always be remembered that efficient condensing depends on the cooling water, and the cooler the inlet water in comparison with the discharge, the greater the number of heat units that are absorbed. At times one hears of wonderful results in the way of vacuum, water quantities and temperatures being obtained with this or that apparatus; but the actual performance is a matter of the exchange of heat units, so that some of the claims that have been made amount to little less than putting a quart into a pint pot.

Taking the various types of plant in order, it may be said that the jet condenser, in its simplest form as used to-day, with many slow-running mill engines, differs very little from those of a hundred years ago. It consists essentially of a chamber *C* in communication with the exhaust pipe and injection pipe *P*, and an air pump to draw out the condensed water and air (Fig. 1). The injection water is usually sucked in from the cooling pond (or lodge, as it is often called), or from a canal without the aid of a circulating pump. In order to obtain better mixing of steam and water, a perforated pipe is now usually used. The air pumps are either horizontal or vertical, and in most recent types of simple jet condenser the pump is placed in the condensing chamber itself, the valves being arranged so that a solid piston may be used. The condenser bodies are made in a number of shapes, but

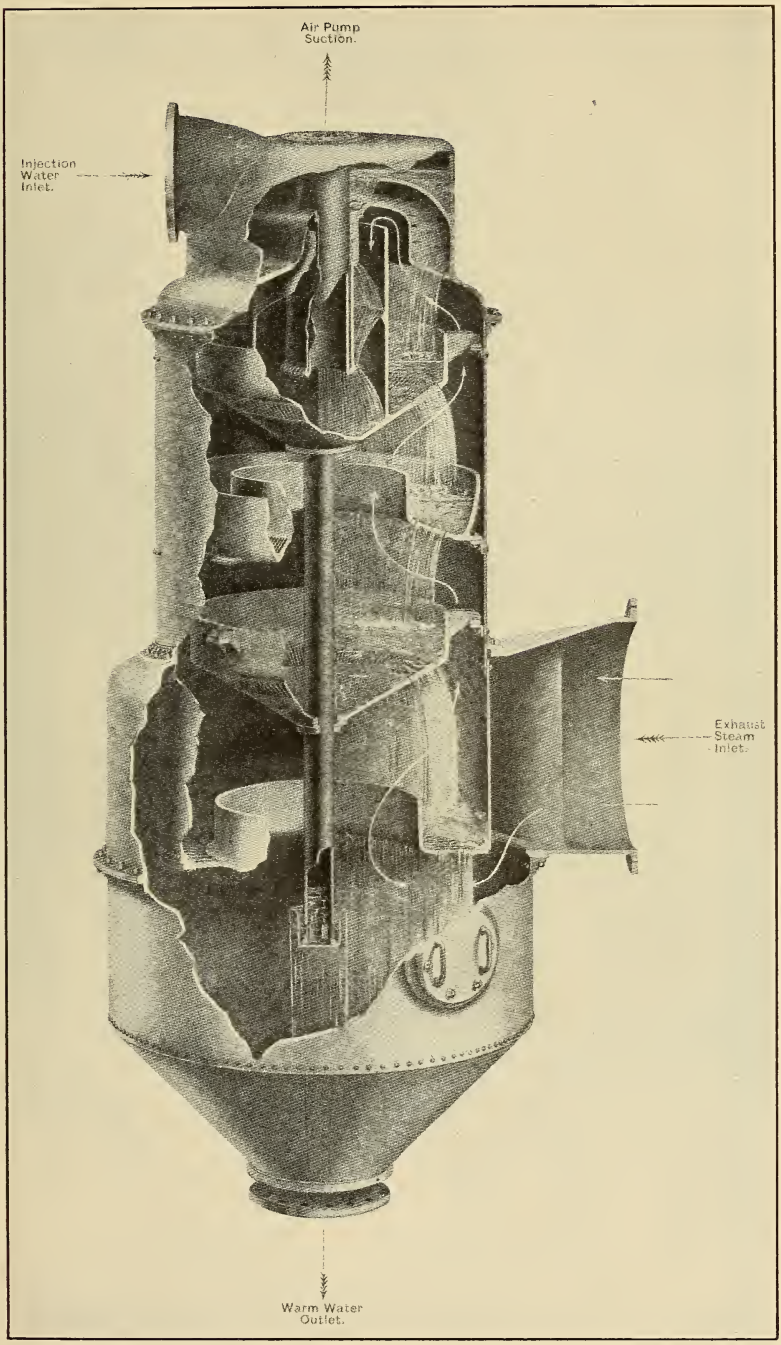

FIG. 4.—WORTHINGTON PATENT COUNTER-CURRENT JET CONDENSER

must be arranged as far as possible to prevent the injection water being drawn back into the engine. Independent jet condensers with horizontal steam-driven air pumps have been largely used, especially in America.

When a high vacuum is required the normal type of jet plant presents some difficulties. The quantity of injection water becomes very large, especially with artificially cooled water, and, therefore, the air pumps become clumsy and expensive. With a very fluctuating load there is also some danger of a back flow into the engine or turbine. These conditions have led to the development of the barometric condenser. This type was first proposed by Watt. A vertical condenser drain pipe about 32 feet long is fitted to the condenser, and, as the barometric pressure cannot keep up this head, there is a continuous discharge. The air pumps, therefore, have to deal only with the air, and not with solid water. It was soon recognized that the higher the temperature of the discharge water the better the boiler efficiency; also, that the lower the temperature of the abstracted air the smaller the volume to be dealt with and the greater the air-pump efficiency. This fact has led to the development of the counter-current barometric condenser. In this type the air is abstracted at the top, where the injection water enters at its lowest temperature, and the water discharge takes place close to the steam inlet, where the temperature is highest. It is also frequently found advantageous to further reduce the temperature and volume of the abstracted air before it reaches the air pumps by passing it through a cooler with cold water circulation, made something like a miniature surface condenser. Fig. 2 is a diagram of a simple barometric condenser fitted with a number of trays to ensure thorough mixing of the steam and injection water. Fig. 4 shows a section of a Worthington counter-current barometric condenser. The feature of this is that the inlet water is discharged in a number of cascades, in long-shaped jets, in such a manner as to thoroughly mix the water with the steam and air, while at the same time offering no obstruc-

FIG. 5.—MULLAN VACUUM PUMP AND SURFACE CONDENSER. C. H. WHEELER MFG. CO., PHILADELPHIA

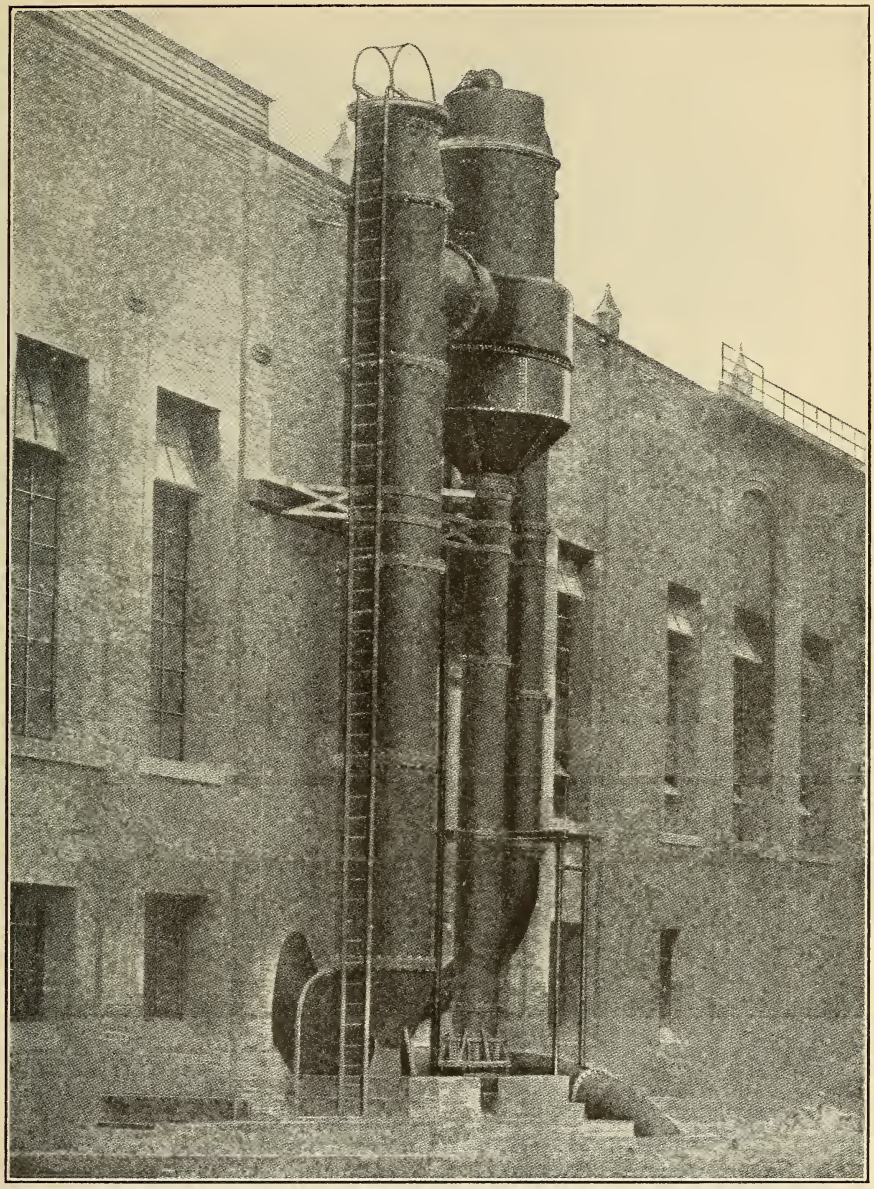

FIG. 6.—WORTHINGTON BAROMETRIC CONDENSER AT THE NEASDEN POWER STATION OF THE METROPOLITAN RAILWAY

tion to the upward passage of the air and vapour. Fig. 6 shows a condenser of this type at the Neasden station of the Metropolitan Railway, with a capacity of 80,000 pounds of steam with circulating water at 80 degrees Fahr.

Fig. 7 shows the arrangement of a Mirrlees - Watson barometric condenser arranged to deal with a very fluctuating load from two large mill engines at the works of David Colville & Sons, Ltd., Motherwell. This installation is arranged with steam-

driven dry air pumps and electrically-driven circulating pumps. The barometric type of condenser is much more suitable for fluctuating loads than the normal type, as the quantity of injection water varies very little with the vacuum; and as the condenser shell is usually placed out of doors, it may be of large capacity to damp down fluctuations and to give a large water capacity. Usually where cooling towers are used two sets of circulating pumps are required, one to circulate round the tower and the other to lift the injection water. Naturally, the condenser vacuum takes care of a certain amount of lift. Where the tower and tank are placed on the roof of a building it is often possible to use only one tower pump and allow the injection water suction to draw directly out of the tank. It should be noted that, with the barometric condenser, an air pump is not absolutely a necessity, as a large quantity of air is, naturally, trapped with the water; but unless very large quantities of water are used the vacuum will not be very high. One advantage of the type of condenser is that the head of water in the discharge leg prevents any flow back into the engine or turbine should the supply be cut off without warning, and this feature had a great deal to do with the development of the type. There is a modified form used sometimes where the headroom is limited, in which the suction of the discharge leg is replaced by a centrifugal pump. In this type, as in several other types of jet condenser, a vacuum breaker is used. A float is placed in some convenient position, and, if the injection water fails, the vacuum tends to draw the water back into the engine; but on reaching the float a valve is opened to the atmosphere, breaking the vacuum and protecting

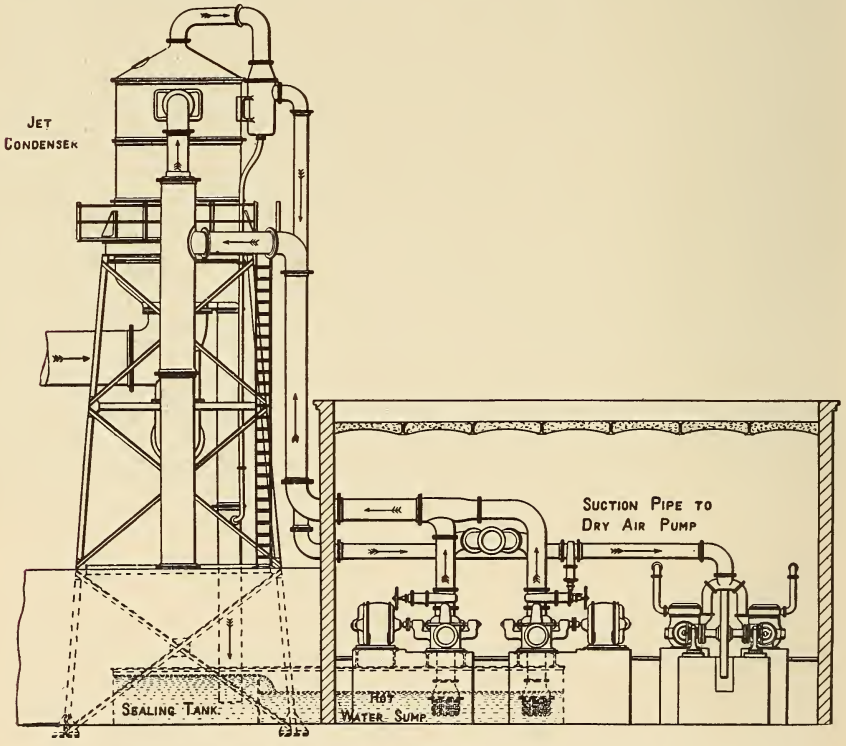

FIG. 7.—MIRRLEES-WATSON BAROMETRIC CONDENSER WORKING WITH THE EXHAUST FROM ROLLING MILL ENGINES

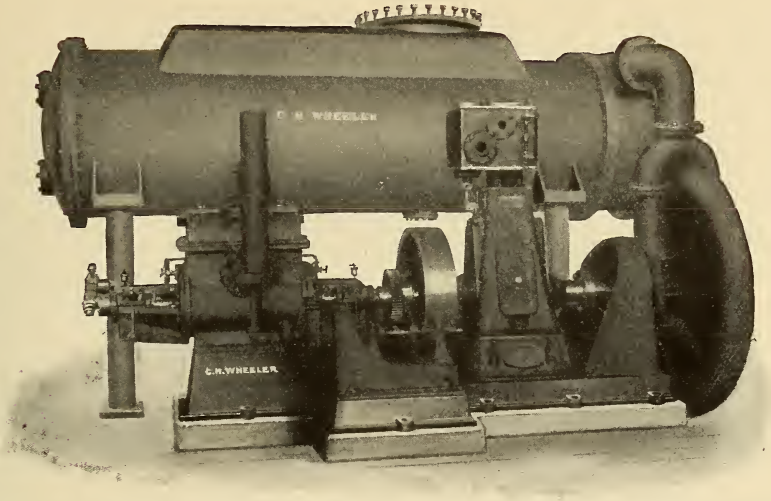

FIG. 8.—C. H. WHEELER SURFACE CONDENSER, ENGINE DRIVEN, ROTREX VACUUM PUMP, CENTRIFUGAL CIRCULATING PUMP AND HOT-WELL LIFT PUMP

the steam plant from damage. Naturally, where a centrifugal pump is used to replace the barometric leg it must be specially designed to work against a large suction head; otherwise it would fail to draw.

A type of jet condenser that has met with a considerable measure of success in the last year or so is that made by the various Westinghouse companies under the Leblanc patents. Fig. 10 shows one of this type suitable for direct connection to the discharge of a steam turbine. The injection water enters through a number of nozzles designed to give a swirling motion to the water, giving intimate contact with the steam. The water and vapour then pass down through the cone *E* with considerable velocity, giving the entrained air a first compression. The air is abstracted at *G* by means of the rotary air pump, and the water is abstracted by means of a centrifugal pump. Both these latter are shown

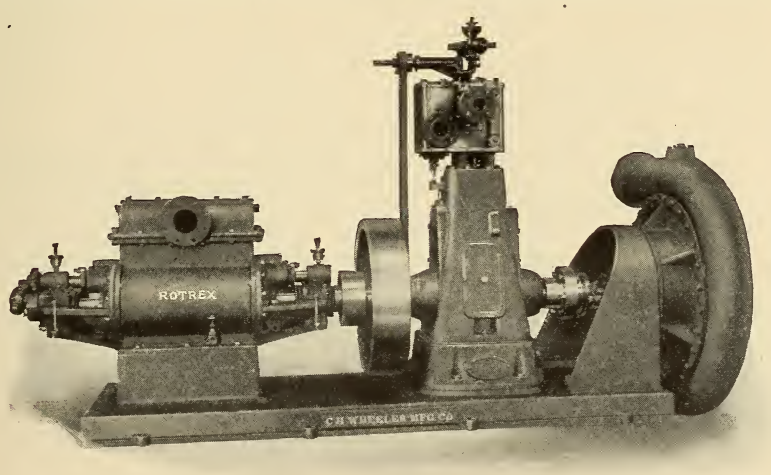

FIG. 9.—ENGINE-DRIVEN ROTREX AND CENTRIFUGAL PUMP. C. H. WHEELER MFG. CO.

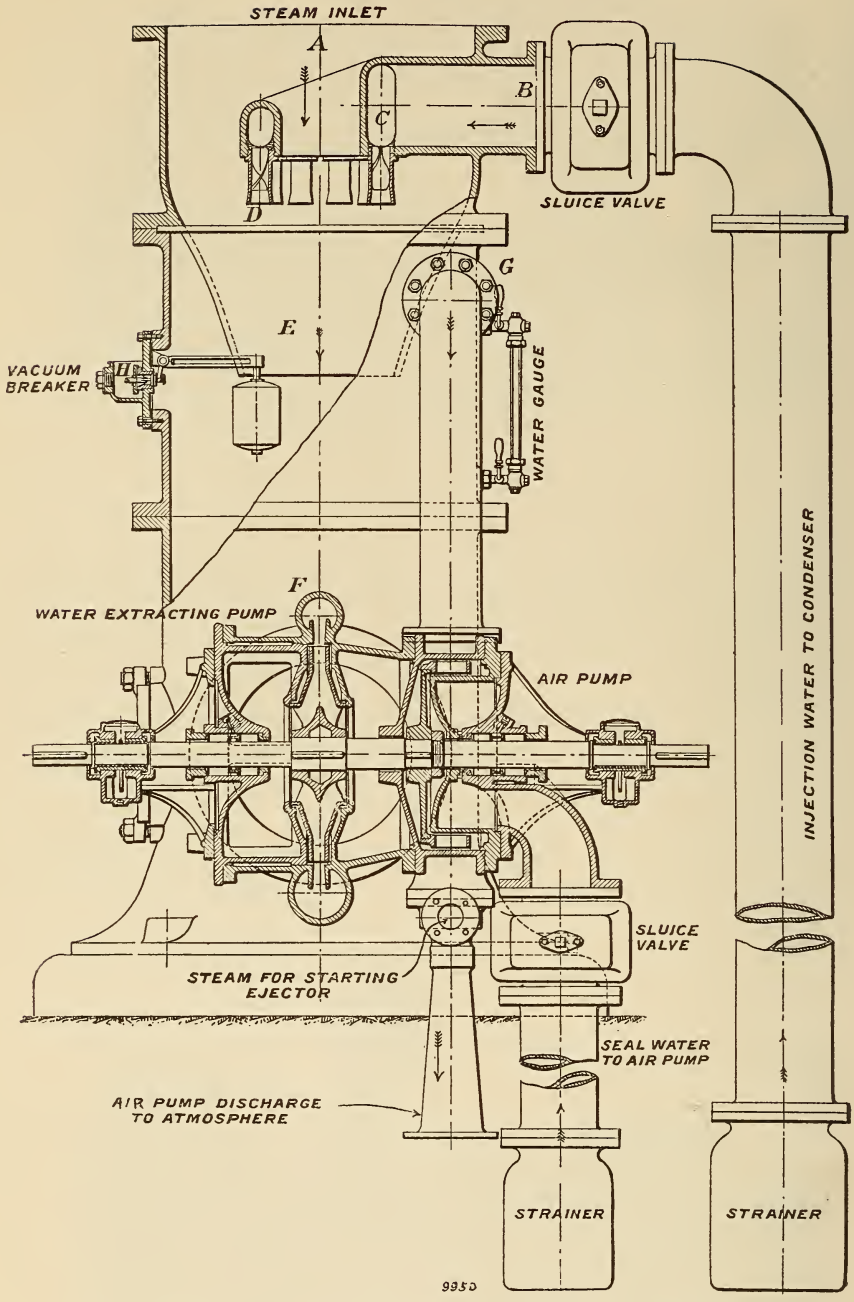

FIG. 10.—SECTIONAL ARRANGEMENT OF LEBLANC MULTIPLE-JET CONDENSING PLANT

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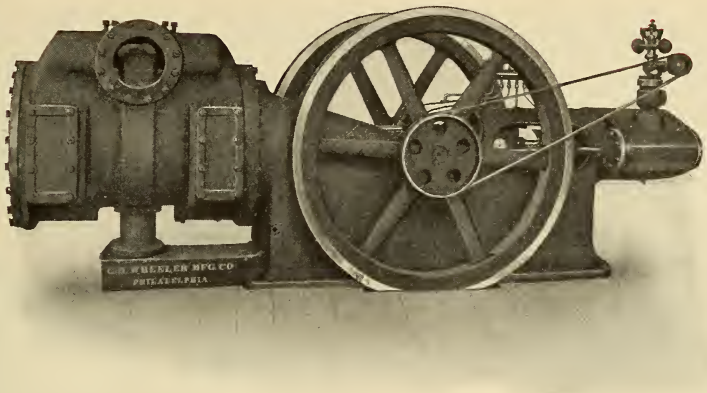


FIG. 11.—MULLAN VACUUM PUMP. C. H. WHEELER MFG. CO.

in section. A float vacuum breaker is used to protect the steam plant in case of water failure. Further details of the air pump will be given later.

An interesting development of the well-known Rees roturbo pump has been recently brought out by the Rees Roturbo Manufacturing Company, of Wolverhampton, the action of the pump being utilized to form a compact and efficient jet condenser. A hollow impeller connected with the water supply is made to revolve at a high speed, and inside the impeller pressure is produced by means of centrifugal force. At the periphery a number of nozzles are arranged in such a way that the jets of water, which issue at a very high velocity, combine to form a number of water fans, like the flame of a bat's-wing gas burner. These fans, in sweeping round a specially formed chamber, condense the steam and entrap the air, carrying it round from the steam inlet to the exhaust outlet. A very high vacuum has been obtained with a condenser of this type.

A type that has been on the market for a number of years, but which has undergone considerable development, to suit the particular requirements of the steam turbine, is known

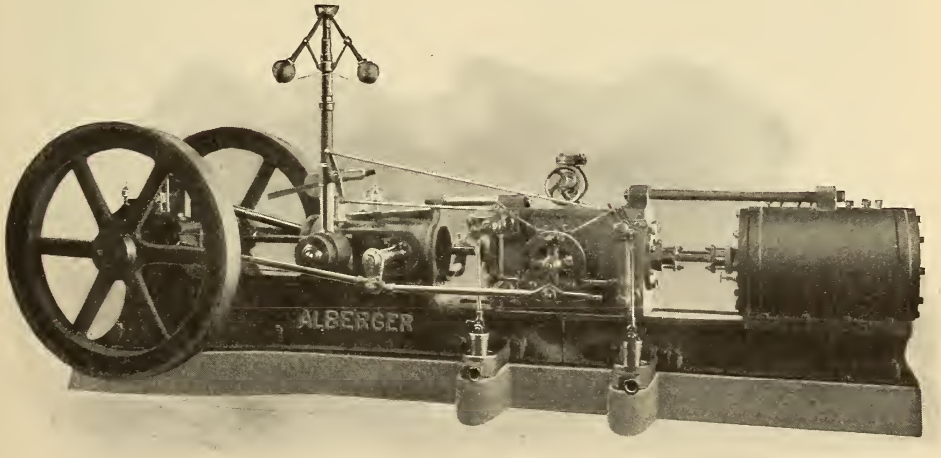


FIG. 12.—CORLISS DRY-VACUUM PUMP. ALBERGER CONDENSER CO., NEW YORK

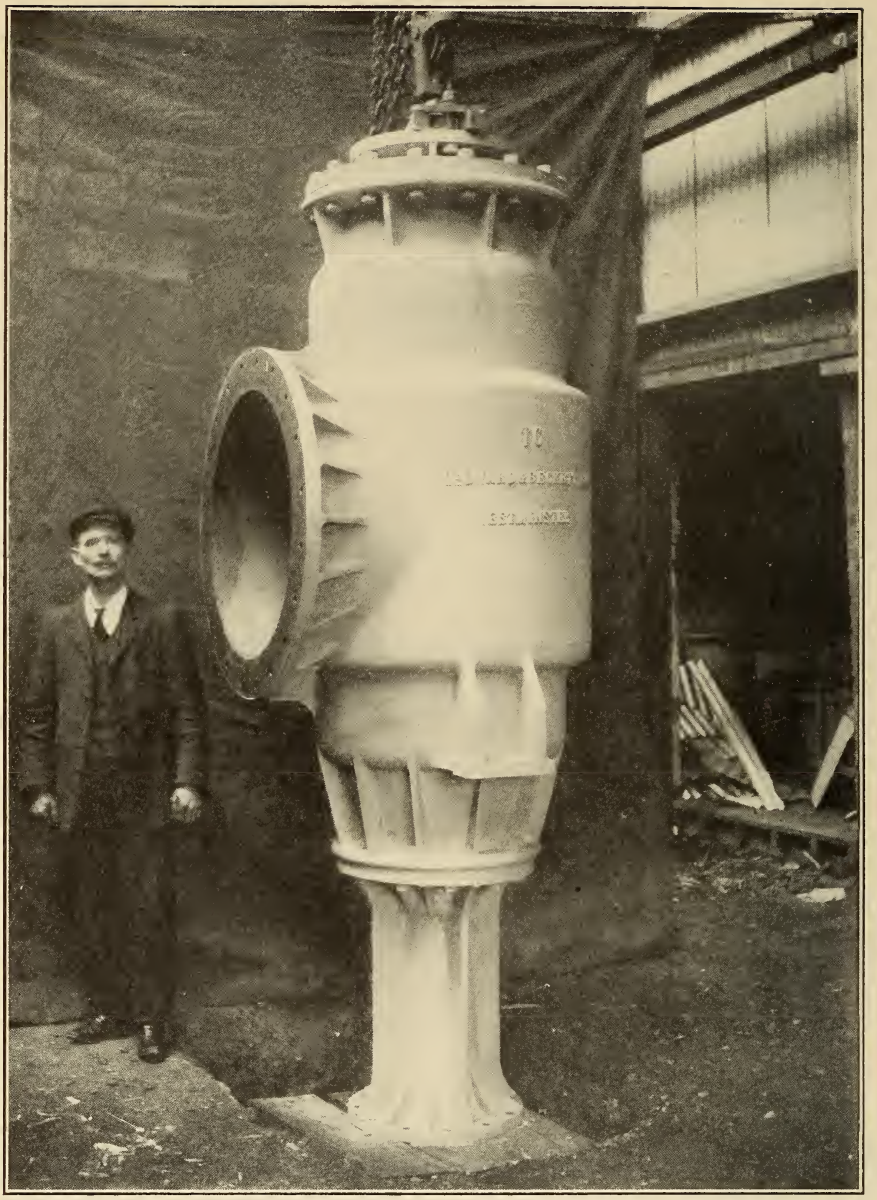


FIG. 13.—LARGE INJECTOR CONDENSER. MESSRS. LEDWARD & BECKETT, WESTMINSTER

as the ejector condenser. This is, without doubt, the simplest type of condenser on the market. A jet of water at high velocity passes through a number of fixed cones. The outside of these cones is placed in connection with the exhaust steam supply, a vacuum is produced, and the steam, mixing with the water in the jet, is carried along with the air into the hot well, no separate air pump being required. In order to give a good vacuum and give stable running, it is advisable to have a head of water of about 15 feet on the jet, though it is quite possible

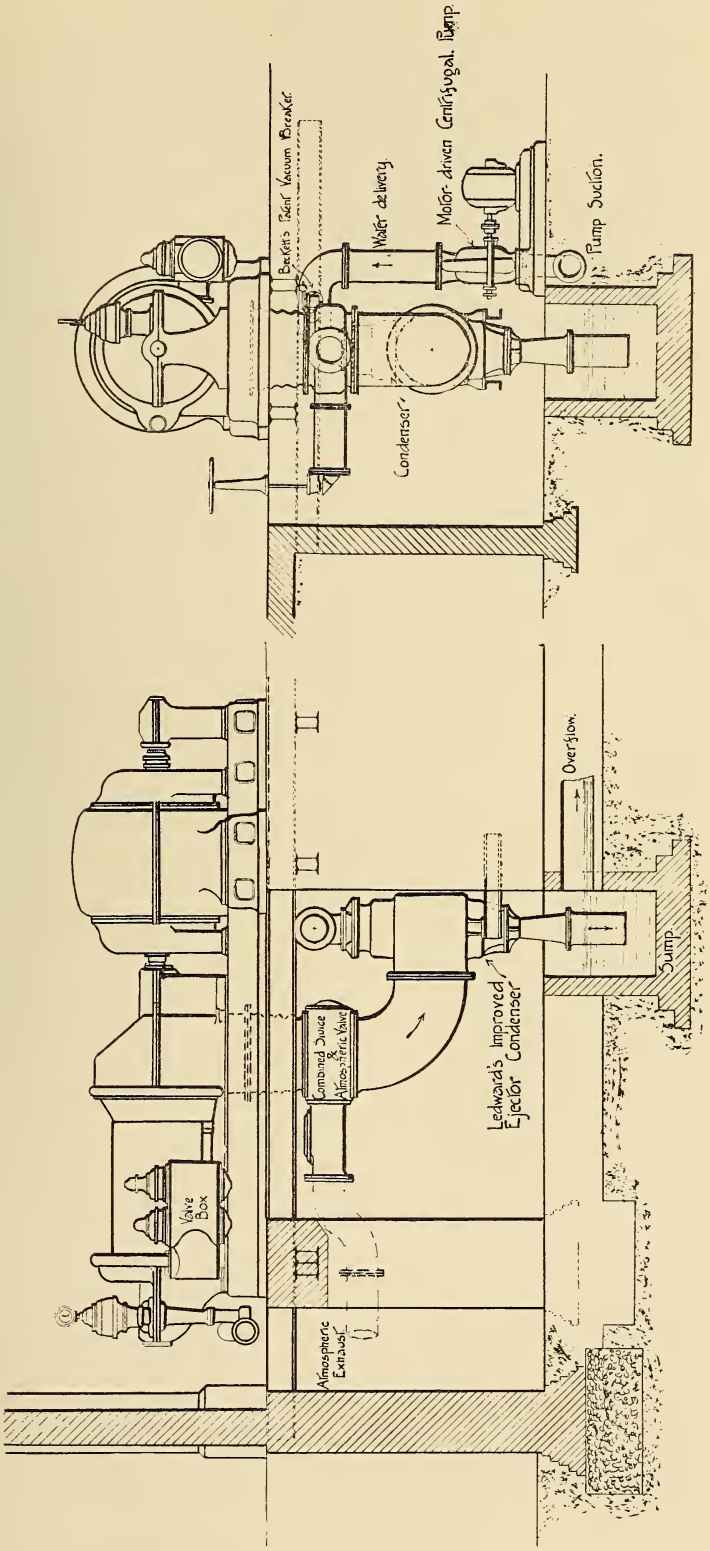


FIG. 14.—LEDWARD & BECKETT EJECTOR CONDENSER WITH PARSONS STEAM TURBINE

when only a low vacuum is required to allow the condenser to suck in its own injection water; but this latter type is not very much used nowadays. For very high vacuum a number of jets are often used. Fig. 13 shows a large ejector condenser made by Messrs. Ledward & Beckett, of Westminster, a firm representative of the best British practice in this class of work. Fig. 14 shows a condenser of this type arranged to work with a steam turbine, the centrifugal pump shown being arranged to give the required head to the water.

There was at one time some prejudice against the use of ejector condensers, as accidents have taken place, owing to the water rushing back into the steam engine and smashing the cylinders if the water supply failed. This was met by the use of an automatic back-pressure valve, which closed directly any water began to flow back through the exhaust pipe. This gives rise, at times, to difficulty with large sizes, and, therefore, vacuum breakers are often used in addition, or by themselves. The usual type of vacuum breaker is operated by means of a float on the rising water, but Mr. Beckett has brought out a contrivance which does not wait for the water to rise, but operates immediately the water pressure of the supply pipe drops below a given point. This arrangement cuts out one step in the relay action, acts instantaneously, and opens to atmosphere through a comparatively large valve. Fig. 15 shows such an arrangement fitted to a Ledward ejector condenser.

Having dealt briefly with the various types of jet condenser, the surface condenser will now be dealt with. It may be said that this type does not lend itself to the same differences of design and construction as the jet condenser, and the differences which exist among various makers are due to differences in shop practice and to the different theories of condenser action propounded by different designers. It is obvious that these conflicting theories cannot all be right, but a pet theory is often a convenient peg on which members of a sales and commercial department can hang an attractive argument for superiority over competing types. The surface condenser consists essentially of a box or chamber with a number of circulating water pipes passing through it. The steam comes in at the top of the box and is condensed, and the condensed water and air are abstracted together or separately by means of one or more air pumps. The circulating connections are so arranged that the water may pass through the tubes through the chamber a desirable number of times backwards and forwards.

In earlier condensers the shape was not looked upon as a matter of any great importance; but nowadays, owing to the demands for high vacuum, much ingenuity is used in order to obtain the best results. The normal type of condenser body is made either rectangular or cylindrical in shape. The former takes up the least space and lends itself to convenient tube spacing; but, owing to the variations in requirements, it is difficult to standardize sizes, and, therefore, patternmaking tends to become an expensive item. With this type of body, in large sizes deep ribs and a number of cross-stays are usually necessary.

The cylindrical body is neater in appearance, and both body and covers can be swept out in the foundry without the use of expensive patterns. Owing to the self-supporting shape, except for the end-tube plate end covers, no staybolts are required.

It is usual to arrange the condenser to give a counter-current effect. To effect this horizontal baffles are placed inside the shell, and connections are made in the water boxes at the ends, so that the cold circulating water goes first through the lower tubes and then through the upper tubes to meet the incoming steam. There are various other de-

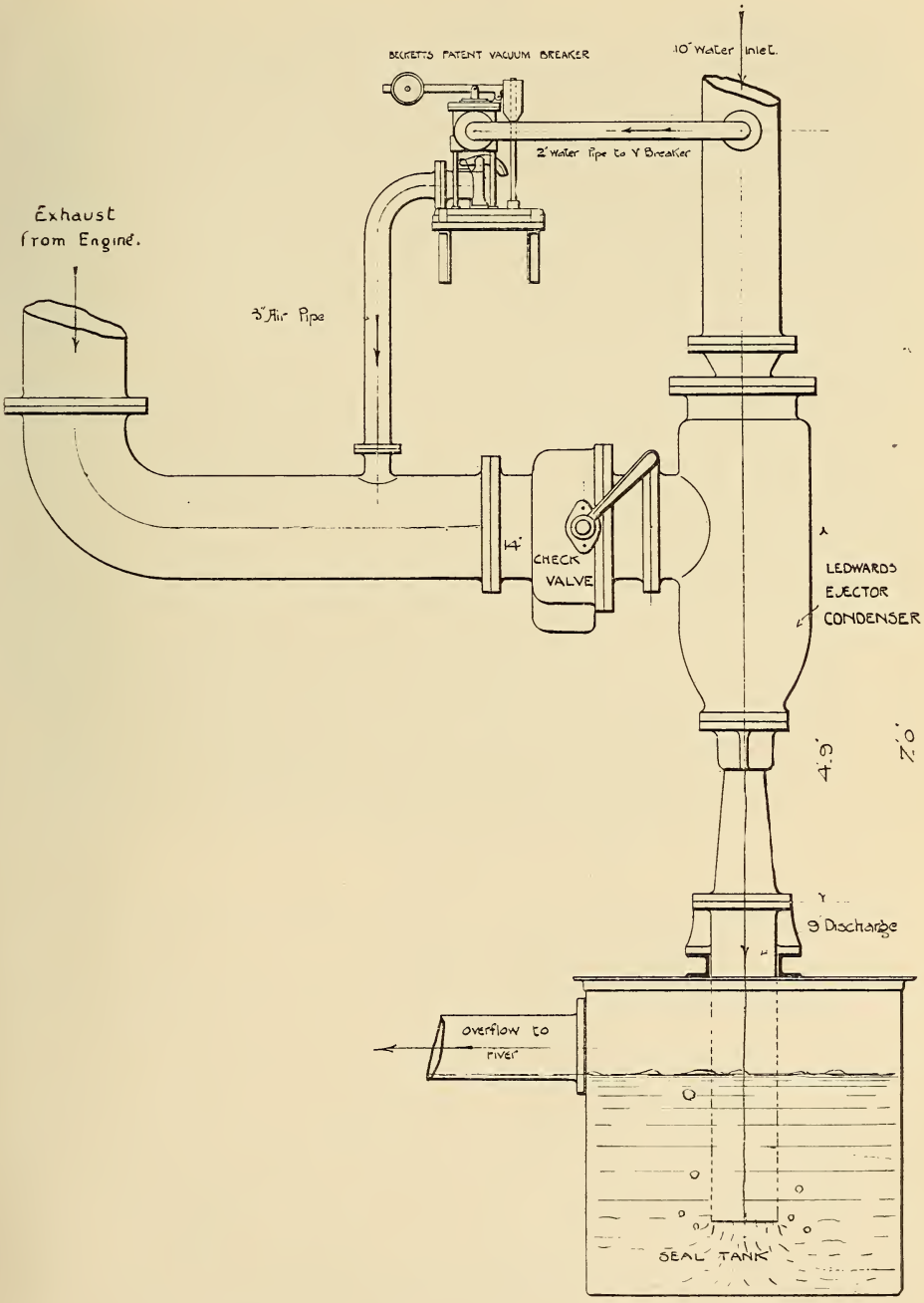


FIG. 15.—GENERAL ARRANGEMENT OF LEDWARD & BECKETT EJECTOR CONDENSER AND BECKETT PATENT VACUUM BREAKER

vices used for the purpose of obtaining high vacuum. For some years Mr. R. W. Allen, of W. H. Allen & Sons, Ltd., used a weir in the air-pump suction inside the condenser, so that a number of the lower tubes were kept drowned by condensed steam, the latter being thereby cooled by the fresh cold circulating water. By this means the temperature of the water and air entering the air pump was reduced and the vacuum materially increased. A theory was later developed that water on the tubes greatly hindered heat transference, and therefore it was desirable to prevent the lower tubes from being kept in a shower of condensed steam drops. The system of compartment drainage was, therefore, introduced by two makers. With this system the condenser body is cut up into several sections, each separately drained, in order to keep the tubes comparatively dry. With this arrangement claims were made for increased vacuum, hotter feed-water and reduced circulating-water quantities, the latter naturally influencing the power required by the circulating pumps. Professor Josse, of Berlin, however, claims, as the result of experiments carried out in Berlin, that the dryness of the tubes has no material effect on the working of a condenser.

In a recent type made by Messrs. Weir, of Glasgow, in large numbers for high vacuum marine work the condenser is made with a wedge-shaped body, with the point away from the steam inlet. With this system the steam passes through the condenser at practically uniform velocity, the steam being unobstructed by baffles of any kind. It should be remembered that the condenser requirements of turbine steamers in

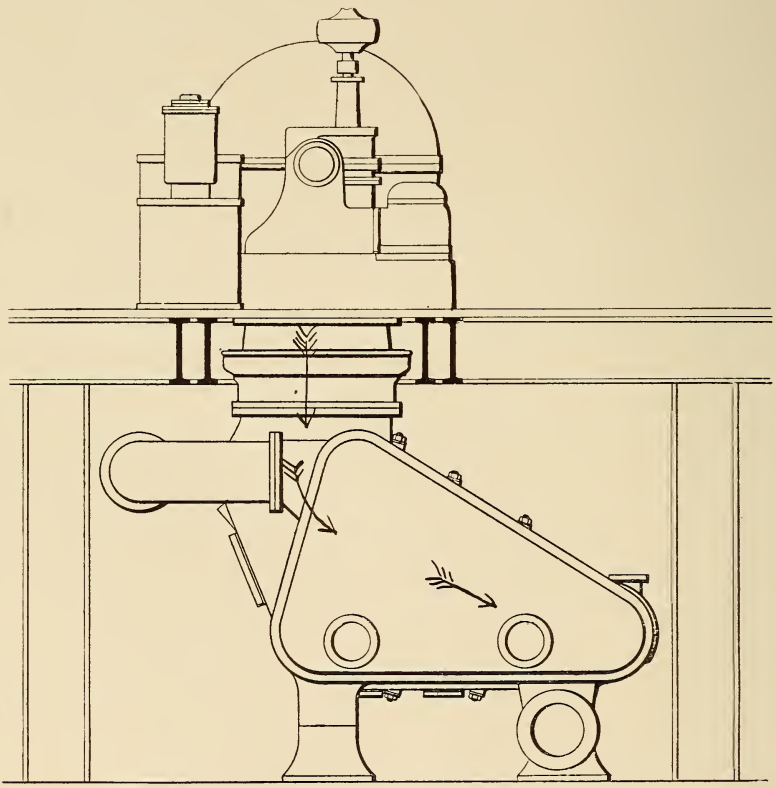


FIG. 16.—OERLIKON TURBINE AND WEIR UNIFLUX CONDENSER

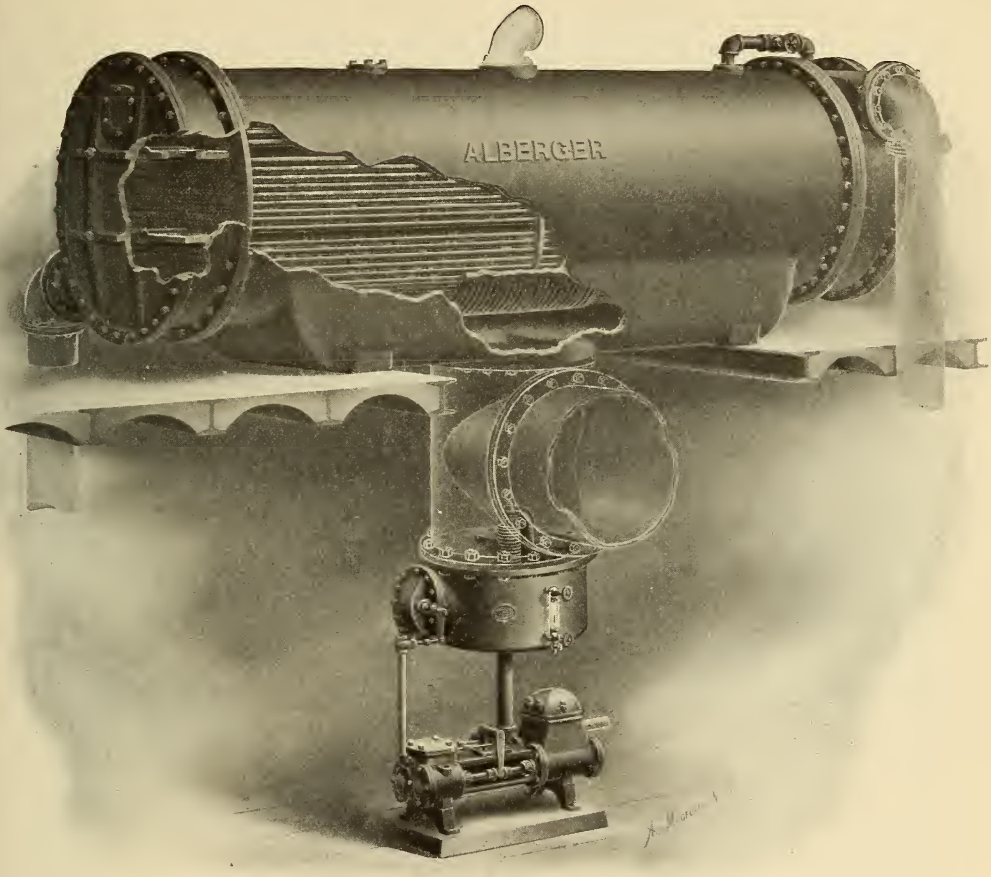


FIG. 17.—COUNTER-CURRENT SURFACE CONDENSER WITH HOT WELL AND CONDENSATION WATER PUMP. ALBERGER CONDENSER COMPANY, NEW YORK

tropical waters approximate very closely to those of the power station with artificially cooled water. Fig. 16 shows the arrangement of one of these Weir "Uniflux" condensers installed at the Wood Lane station of the Kensington & Notting Hill Electric Lighting Company, from which very excellent results have been obtained. There are various other arrangements used by different makers to obtain high vacuum. Messrs. Parsons use their well-known vacuum augmentor. With this appliance the air is compressed by means of a steam jet and then passed through an air cooler, being dealt with by the air pumps. Not more than 2 per cent. of the steam condensed is required by this jet, and the bulk of the heat of the jet steam is returned to the boiler through the hot well.

There is a general tendency towards the use of separate air and water extraction pumps. This enables the utmost benefit being obtained from hot feed-water and cold air discharge.

It is accepted that a high velocity in the tubes, together with a good temperature gradient in the condenser, tends toward good results; but this must not be pushed too far, as the loss in head, due to high velocity

and the number of reversals in the water boxes, where eddy losses are likely to be so serious, can very quickly, through excessive circulating pump power, neutralize the advantage gained; in some cases there is a loss of head of nearly 30 feet between inlet and outlet flanges. This question does not always get the consideration it deserves.

Where the circulating water is very dirty a vertical condenser with comparatively large tubes may be used with advantage. With this type it is possible to arrange so that the tubes can be cleaned from the top without shutting down. Fig. 18 shows a condenser of this type supplied by Messrs. Mirrlees-Watson & Co., Ltd., Glasgow, to the Corporation of Leeds. Arrangements are made so that the direction of the circulating water can be reversed. This helps to clean the dirt out.

A class closely allied to those of the surface type is the evaporative condenser. These are either made for natural draught or for forced draught. There are not many of the latter type in use in power-station work. The former consists of a number of cast-iron pipes placed in rows in the open air, a large contact surface being obtained by means of internal corrugations and external ribs. The steam is led into the pipes by means of suitable branches, and the necessary cooling effect is obtained by pumping a comparatively small quantity of water over the pipes. The water evaporates, and this, together with the radiation and conduction, condenses the steam in the pipes. The air is abstracted by means of a normal type air pump. This class of condenser, although unsuitable for the very highest vacuum, and although somewhat expensive in first cost, is noted for its great economy in working where a natural supply of condensing water is unobtainable. No cooling tower is required, and, instead of thirty or more times the feed having to be circulated at a tower head of 30 feet or more, something less than a gallon per pound of steam has to be raised about 10 feet, and at low loads no water need be circulated at all. The loss of circulating water is very much less than with any other type of artificial cooling plant—a matter of some importance when water is scarce or has to be paid for by meter. In several recent instances it has been found more economical, with plant of medium

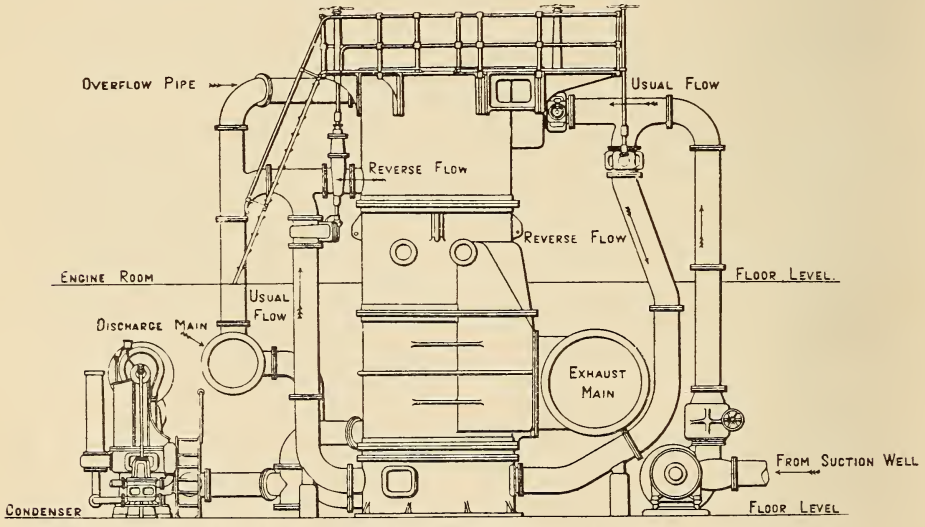


FIG. 18.—OPEN-TOP SURFACE CONDENSER OF THE MIRRLEES-WATSON TYPE, AT LEEDS CORP. ELEC. LIGHTING STATION

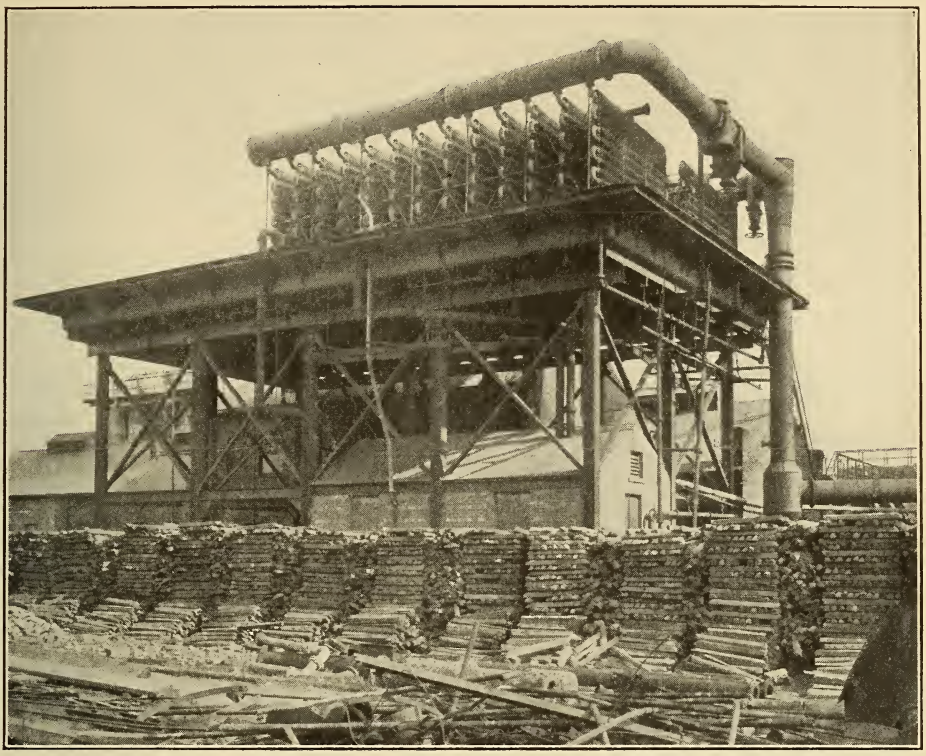


FIG. 19.—EVAPORATIVE CONDENSER MADE BY LEDWARD & BECKETT, LTD., LONDON, DEALING WITH THE EXHAUST FROM A PARSONS TURBO BLOWER

output, to install a steam engine with an evaporative condenser rather than a steam turbine with surface condenser and cooling tower.

This type of condenser has also been used with success in connection with steam turbines. Fig. 19 shows a condenser made by Messrs. Ledward & Beckett, Ltd., London, dealiug with the exhaust steam from a Parsons turbo-blower, giving a vacuum of 27 to 27½ inches. As may be seen, the whole condenser and tank is mounted on steel columns. In order to get hot water for feeding purposes, a part is drawn off from the condenser pipes as soon as it condenses by means of a special pump. One would imagine, at first sight, that a large mass of piping difficulties would be met with from air leakage at the numerous joints. No trouble has, however, been experienced in this direction. Messrs. Edwards, Dean & Beale, Ltd., of London, S. E., have also made a number of successful evaporative condensers. The pipes in their system are made somewhat oval in shape, the internal corrugations being flattened out at the bottom in order to facilitate drainage (Fig. 20).

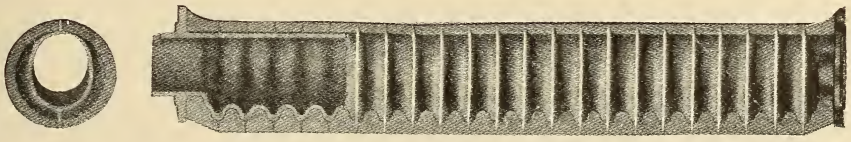


FIG. 20.—CORRUGATED TUBE FOR EVAPORATIVE CONDENSER

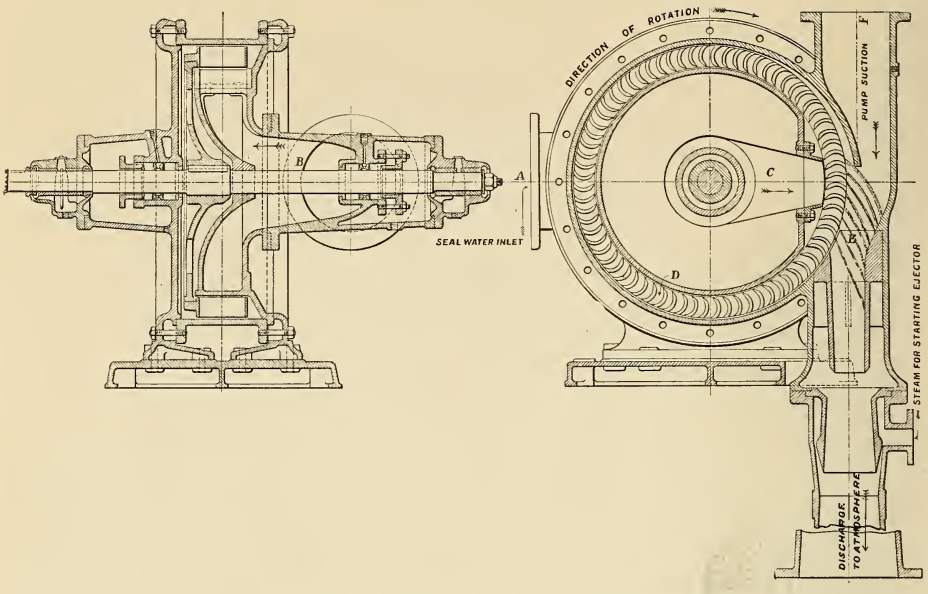


FIG. 21.—SECTION LEBLANC ROTARY DRY AIR PUMP.

At one of their recent installations the electrical power required for circulating has not exceeded 0.63 per cent. of the total units generated per annum—quite remarkable results. A novel type of evaporative condenser has recently been introduced in America. The arrangement is very similar to that of a surface condenser, air being circulated through the tubes instead of water. A spray is placed at the air inlet and circulation is maintained with a fan. A number of condensers on the same principle have been in use for some time in Great Britain, the steam to be condensed, however, being inside and not outside the tubes.

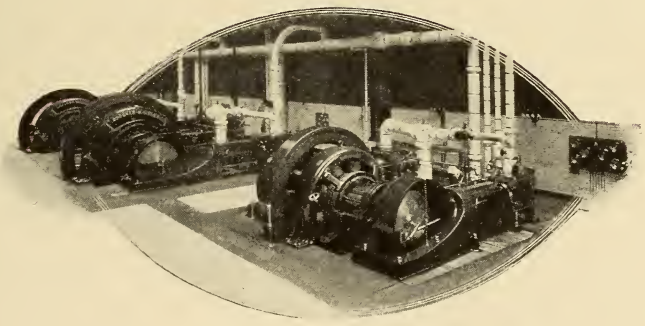
Messrs. Fouché, of Paris, have for several years made a combined condenser and air heater for use in factories, the heated air being delivered to the workshops through suitable trunks with the aid of a fan. No spray is used, and the vacuum obtainable is not high.

Taking the question of auxiliaries, the steam drive has largely given place to the electric drive. For a number of years the Edwards air pump held almost undisputed sway in power-station work, although recently a number of rotary air pumps have been installed. These latter, although neat and convenient, have some difficulty in competing with the former in power consumption, as the breaking up of water into high-velocity jets, sprays or films usually requires a large amount of power. There are several types on the market—the LeBlanc, the A. E. G., the Worthington, the Roturbo, and others—of which the LeBlanc was perhaps the first to be put into practical use. In all these pumps water in some form is used to entrap the air. Rotary air pumps are used in connection with both jet and surface condensers. The LeBlanc air pump is shown in section in Fig. 21. Sealing water is introduced into the port *C* through the branch *A* and central chamber *B*. The water is then caught up by the blades *D* of the high-speed Pelton wheel and ejected into the discharge cone *E* in thin sheets. These high-velocity sheets form absolutely tight water pistons in the discharge cone, entrapping the air from the condenser through *F* and discharging it against atmospheric

pressure. In order to start up, a steam jet ejector is used. This type of pump is made in a number of patterns to suit different classes of work.

With regard to circulating pumps, those of the centrifugal type practically hold the field, especially for large outputs, the two-stage type being occasionally used against high heads for cooling-tower work. In the case of high heads and surface condensers, in order to relieve the tube plates of pressure, the circulating pump is usually arranged to draw through the condenser.

Space has prevented the author from touching on several interesting makes of plant, but the whole question of condensing in these days of necessary small economies is of such importance that an extensive treatise would be required to do justice to the subject. Condenser manufacture has become almost a trade in itself, and, in view of the number of different types on the market, the choice of a condenser is a matter requiring the greatest care and circumspection on the part of the power engineer in the light of the best practical experience.



THE GREAT TRANSFORMATION

By Henry Harrison Suplee

VIII. CONCLUSION.

"Men, my brothers, men the workers, ever reaping something new,
That which they have done but earnest of the things which they shall do."
Tennyson, Locksley Hall, 1842.

IN the preceding articles some indication of the consequences which may be expected to follow the general introduction of aerial navigation have been given, but it is desirable to review these and to separate in the mind of the reader the fundamental principles from the details of the coming change. Running rapidly over the salient features of the subject, we may emphasize the following points:

Until the present time all real property has been that existing upon the surface of the earth. Present titles date back to royal or other grants, these being based upon the right of conquest or discovery. Land titles have been assumed to run downward to the centre of the earth and upward to the heavens, but the former is not always conceded in the case of mining claims and the latter has been shown to be incapable of defense, as in the case of radio-telegraphy, and, more recently, in the case of flying machines passing over private property, over international boundary lines and over fortifications.

The only reason why the air has not been appropriated and partitioned out as property has been the impracticability of maintaining possession. Governments have endeavored to prohibit amateurs in wireless telegraphy, but their weakness has been shown by their powerlessness to prevent the passage of the electrical waves.

It has long been realized that the successful development of aerial navigation would involve a readjustment of commercial, political and military relations. This period is already upon us, and yet no serious effort has been made to effect that readjustment. If existing customs regulations are to be enforced, it will be necessary to provide an aerial patrol to prevent smuggling, and the extent of boundary to be covered will be immensely increased, or else it will be conceded by governments that free trade has already become a fact by reason of engineering developments and not by political policy.

The lines of boundaries have been heretofore determined by surveys upon the surface of the earth upon the supposition that all crossings would have to be made upon recognized surface highways. When the routes through the air are made available without the consent or permission of official authority, the entire idea of international boundaries will have to be abandoned or an aerial patrol along the entire line instituted, not only at some legally agreed level, but at any level which the individual may elect to use.

Military fortifications have been heretofore designed wholly with respect to invasion upon the surface of the land or water. Their entire history shows that they have been planned in connection with the range of weapons in vogue at the time when they were built. As the range of artillery was increased the construction of fortifications has been necessarily modified until it has been found that no system is capable of long duration, while the cost has

continually been increasing, and the unused equipment has had to be scrapped at frequent intervals.

In nearly all instances the men who held the issues of war or peace in their control have been in places remote from the front, secure from personal injury, whatever their decision. With the control of the air, it has already become possible for the first attack to be made upon defenseless legislative bodies, so that the men who make or prevent war will be the first to feel the results. There is already no *front,* geographically speaking, but rather an exposed *surface* beneath, upon which the enemy may select his point of attack, regardless of the disposition of the surface forces.

The present success which has attended the employment of radio-telegraphy from aeroplanes and dirigibles demonstrates that the entire bird's-eye view of the enemy may be disclosed to the opposing forces, so that secrecy in the sense hitherto employed is impossible. All plans now under execution or consideration for the maintenance or construction of surface fortifications have become obsolete by reason of the increased range of overhead weapons. The fortification of the Panama Canal is a grotesque proposition so long as the locks and power houses are open to attack from above. The demonstrated possibility of launching an aeroplane from a vessel at sea or from the surface of the water and assuring its safe return has rendered such fortification wholly out of date even before the work has begun or even taken form in the minds of its projectors and constructors.

Under such conditions some of the most important matters before legislators and military authorities are the readjustments which must be compelled in legal, military and commercial matters. New property rights will have to be devised which shall lie within the powers of courts to enforce, and it must be realized that enactments which cannot be enforced will take their places along with those of the mice and rats to bell the cat. Attempts to maintain international boundaries must be abandoned, together with all efforts to examine merchandise, luggage or persons, these ideas becoming as antiquated as would be any attempts to control the movements of individuals within national limits. Universal free trade must follow the failure to control individual crossings of frontiers, and the right to go anywhere in the world, regardless of official wishes, will have to be conceded by reason of the powerlessness of officials to know or do anything about it. All idea of regulation of personal or commercial movements will take its place along with mediæval attempts to regulate individual opinion, becoming a curious and obsolete fact in history, comparable with the relation of the Inquisition as regards freedom of thought in religious matters or freedom of conduct in matters political.

We are, then, face to face with a problem which is in the position of being capable of solving itself and not dependent upon the action of legislative bodies.

Emphasis has already been placed upon the point that no revolutionary changes are to be expected. There will be no sudden overturning of existing conventionalities and no immediate invasion of long-established rights.

The transformation which has been indicated will probably proceed in much the same manner as those which have followed the introduction of other mechanical devices into the general activities of life. The growth of the use of the steam engine, the steamship, the locomotive or the automobile, while rapid, was not so sudden as to disturb the social equilibrium of the world in a moment, and yet the consequences of those developments in applied science were far more profound and more effective than were the results of such violent disturbances as accompanied the overthrow of the French monarchy

or the abolition of negro slavery.

It is well known that events which are accompanied with violent outbursts of energy in short periods of time are notable mainly because of their spectacular character, out of all proportion to their real importance. The single invention of the cotton gin meant far more to the wealth and industry of the Southern United States than the entire struggle over slavery. The war between France and Prussia in 1870, costing France two provinces and five milliards of francs, was more than overbalanced in monetary value by the quiet work of a single scientist.

Nearly every important transformation which has been effected in national affairs and in social conditions has been the work of some unpretentious individual, to whom participation in political or military affairs would have been most distasteful. It is known that the difficulties accompanying the association of a civilian with naval activities was the reason which prevented the submarines of Fulton from being employed by France against England, while the reluctance of Ericsson to appear before the naval board almost imperiled the construction of the *Monitor* and the fateful consequences in Hampton Roads.

In like manner, the influences of the work of the Wrights, of Blériot, of Chanute and their associates will fall into line with the entire progress of affairs, and by the time the salient features of the transformation have been effected they will seem altogether logical and inevitable to those who partake in them.

The facility with which the entire community accommodates itself to radical changes is not always appreciated, and, as has already been noted, the magnitude of certain developments can be realized only by observing the difficulties amid which we exist when temporarily deprived of them. During a single generation the work of the engineer has provided society with the telephone, the passenger elevator, the electric railway, both municipal and interurban, the automobile and the gasoline motor. Each of these has wrought a transformation in the life of the business man, the suburban resident, the farmer and the mechanic. These changes have been produced quietly, unobtrusively, and yet so effectively that if these wholly mechanical auxiliaries to every-day life were suddenly removed the greater portion of our social activities would be paralyzed.

It would be difficult for the average individual of to-day to tell, with any degree of precision, just when the telephone began to influence the conduct of his affairs, and yet, when the service is temporarily interrupted, he finds it utterly impossible to go back to the old condition of things before a frail wire formed the principal means of oral communication with his fellow men.

The fire which interrupts the service of the electric railway, whether on or beneath the surface, also disorganizes entire business operations which, a few moments before, would scarcely have realized when or how the interdependence began. These are but isolated examples of the manner in which transformations without violent revolution have occurred, impressing us with the belief that, in a similar way, corresponding developments in other lines may be expected.

Most of the changes which have already occurred as results of the general introduction of mechanical appliances have been opposed, either by minimizing their probable importance, as in the case of the railway, the telegraph or the automobile, or by violently objecting on industrial grounds, as against the spinning mule, the power loom or the lifting magnet.

These sentiments are beginning to appear in connection with the progress of aerial navigation. Although the crossing of the Channel, the passage of the Alps and the flight from the Atlantic to the Pacific have already

been accomplished, the dullness which passes for conservatism declines to perceive the unmistakable indication of coming changes. The command of the forces of Nature by the engineer for the use and convenience of men has scarcely begun. Natural resources, about the conservatism of which so much has been said of late, form only the material portion of the things with which he must do his work; the imponderable forces and manifestations of energy at his disposal are barely realized, much less controlled.

One of the curious points which occasionally crops out in the occult philosophy of the East appears in the idea that the powers which, it is taught, are attainable by meditation and spiritual exaltation, may also be ultimately acquired in a wholly physical manner as the result of sheer intellectual development applied to material resources. Whether the spiritual progress of the venerable East shall be overcome by the material activity of the West remains to be seen, but it is at least interesting to realize that the possibility of attaining the same end by such apparently opposite methods has already been considered by the older thinkers.

While the transformation especially considered in these chapters is that which may be expected to follow the general realization of aerial transport, this forms but one of the changes which will appear as the future control of the forces of Nature is developed. Practically the entire system of government at the present time is based upon the ancient idea of domination by physical force, originally derived solely from muscular strength of man and beast and later aided by the application of explosives to purposes of destruction.

Already there are many indications of the waning of this antique conception of the social structure, and it is appearing that the entrance of the engineer into the controlling activities of society will mean such a reversal of relations as will make him master instead of servant, so that ability to control the forces of Nature will become the criterion of fitness for supreme command, while the former qualifications for eminence, such as persuasive powers of speech, familiarity with laws of man rather than those of mechanics, and the like, will be subordinated. This, then, will constitute the real Great Transformation, a change which is coming in many ways, all tending to this one end, a change of which the development of aerial navigation is but a single element.

When the individual may go freely where he pleases, communicate through space and control mechanical power freely for all physical efforts, the Great Transformation will be fully effected. It began with the quiet model maker in the University of Glasgow, it was continued by the courtly American artist, by the persistent German mechanic, by the industrious Italian physicist, by the silent Ohio bicycle builders. It cannot be stopped, it may not be ignored, and if it is to be guided the time is now ripe.

SOME RECENT DEVELOPMENTS IN BRITISH MACHINE-TOOL DESIGN

By Joseph Horner

THE unbroken procession of machine tools of new or of older but modified designs which issues from the workshops of the great industrial countries is a marvelous phenomena. The men of a generation since must have believed that the machines built then were practically stereotyped for a long time to come. For each great group of machine tools was constructed on nearly identical lines in regard to patterns and proportions during a period of, say, twenty or thirty years. There was a set of patterns for lathes of certain dimensions, one for planers of the same class, another for drilling machines, and so on. Another fact is that many machines which are now regarded as of first importance were either unrepresented at that period, or they existed only in some obscure and weakly prototypes which attracted but scant attention and aroused little interest. Moreover, the methods of production employed in the shops then involved a large amount of hand work, especially in the finishing stages. Tedious scraping was practiced extensively and rapid precision grinding was almost unknown. The conception of interchangeable parts with the methods necessary to their production had not been accepted by the machine-tool makers and the general engineering establishments. Even the duplicate parts and spares required in the case of most engines and many machines could not be relied on to go into place without some adjustments on the part of the fitter. It is only necessary to recall these things, which are still fresh in the memory of middle-aged men, to realize the immense gulf which separates the present from that very recent past.

The aspect of this subject, which we propose to consider in this article, is that each radical advance has been made either in consequence of some important new mechanical invention of development or of an intensification in manufacturing and commercial rivalry.

Familiar examples of the first kind are demands made for heavier machine tools by the growth of very massive engineering structures to which the employment of steel in castings, plated work and forgings has contributed. The enormous extent of the cycle and motor vehicle industry and of electrical machinery has been responsible for many new machines. The requirements of electric tramways have called a number of new machine tools into existence. Machines are built for turning wheels, boring bearings, turning and grinding commutators, for banding armatures and for coil winding. Machines have been designed or remodeled in response to the requirements of steam turbine builders, large gas engine makers, and so on. In each of these important fields numerous machine developments are clearly traceable to the requirements of the new inventions or developments.

Subsidiary to the principal machine tools are vast numbers of satellite machines employed in the production of castings and forgings, in cutting off, screwing, grinding, sharpening, stamping, etc. These have been evolved, remodeled, or improved in order to deal with the increased quantities of the classes of work re-

quired. To mention only a few, there are moulding machines, many of which are built to handle one class of castings only; forging hammers and presses for light and for massive work when done in large quantities occur in many designs. Bar work appropriates many cutting-off machines and saws, the numerous turret lathes and automatics. Grinding occupies an immense field and includes new spheres, notably that of grinding cylinders and pistons, crankshafts, cams and other details for petrol and oil engines. The stamping which the blades of steam turbines entails has created a new industry in press work. In fact, a survey of the new and vast fields which have been opened up by the new mechanical developments becomes bewildering.

Examples of the second kind of machine-tool developments are those which are consequent on the intensification of manufacturing and commercial rivalry. These are comparatively recent. They really date from about the period when the United States began to send over machine tools in quantity for the manufacture of cycles, machines which, some of which greatly improved on, have found their way into the general engineering establishments. Later came the imports from the German Empire in the shape of machine tools and electrical machinery. These have exercised a very salutary influence on our own manufactures. When a few years ago notes of alarm were being raised in England over the invasion of American machine tools, British practice was at a low ebb. Designs that were obsolete in every way were still being built by most of the firms. But fortunately the cosmopolitan rivalry was productive of good, so that now the best British-built machines are undoubtedly superior in capacity, strength, economy, and general handiness to machines of a similar class built abroad. British character seems reflected in the designs, and an amount of solidity and strength is reached which a great number of foreign makers only arrive at after a process of increment in succeeding designs. And still, existing conditions are such that no manufacturer, however eminent, can feel sure that any one type of machine or machine tool for the production of which his plant is laid down, and his methods arranged, may not be superseded if not rendered obsolete at no distant period.

Such is a meagre outline of the story of the rivalry of the manufacture of machines, to some of the more salient features of which we now turn.

Ten years ago all the ordinary run of engineers' lathes were built on practically identical patterns, and in not very diverse proportions, notwithstanding that most firms claimed in vague terms extra strength and extra dimensions for their own products. With the introduction of tools of high-speed steels, the revolution in design has been such that no single element in these old lathes has been retained in the new, but the remodeled design has been absolute, astonishing and unprecedented. A result is that every maker of lathes has been compelled to scrap the old designs, besides which new firms have entered into the field.

The lathes are instanced because they are familiar and typical of other machine tools. But what has happened in the lathes has occurred also in boring and drilling and milling machines, and in many others. History repeats itself here, for the essential elements of the old lathes, cones, back gears, tool holders and slides are all reproduced in many other machines.

The passing of the step speed cone is not a figure of speech, or a doubtful anticipation. It is a long way towards being a fully accomplished fact. The all-geared head daily grows in favour. The shifting of a broad heavy belt transmitting, say, from 20 to 60 horse-power, is a difficulty that favours either the single-belt pulley drive or the vari-

able motor drive, and the changes made in gears instead of by belts, which for speed and feed changes are now getting nearly obsolete. With these radical alterations nearly every other detail becomes modified. It is no longer a case of putting a big head on an existing lathe, as was formerly done. The whole lathe has had to be remodeled on more massive lines in order to enable it to fulfill the duties which are imposed upon it by the high-speed tool. And so also in the case of other machine tools.

Many of the capstan and turret lathes are, like the ordinary ones, fitted with all-geared heads. Firms will supply either this or the step-cone design. A fully equipped engineer's lathe of this kind includes a chasing bar, with a short guide for cutting short lengths of screws in a small range of pitches. Such a tool, by Messrs. James Archdale & Co., Ltd., of Birmingham, is shown by Fig. 1. It includes the usual equipments of hexagon turret, cross-slide to carry either the tool posts shown, or a square turret for four tools on the front. Stops are provided for all the movements, and gear changes are provided for the feeds. Eighteen spindle speeds are obtained, while there are four changes of feed to the capstan, and the levers which control these also control the feed shaft. A reversing motion is fitted so that right and left hand threads can be cut. The hollow spindle running in ring-oiled gunmetal bearings has a ball thrust. The automatic chuck is lever operated.

The advent of the all-geared head has resulted in new problems and conditions of a subsidiary but difficult kind, which can barely be indicated here. All such gears are of fine pitch; hence the problem of durability entails the employment of special steel, frequently now some of the numerous high-priced alloy steels are employed. Then these are, in the case of the larger gears, simply a ring of teeth fastened to a body of cheaper metal. Another problem is that of the best method of cutting the teeth, and again that of grinding them. Further, some prefer sliding gears, others loose gears and sliding

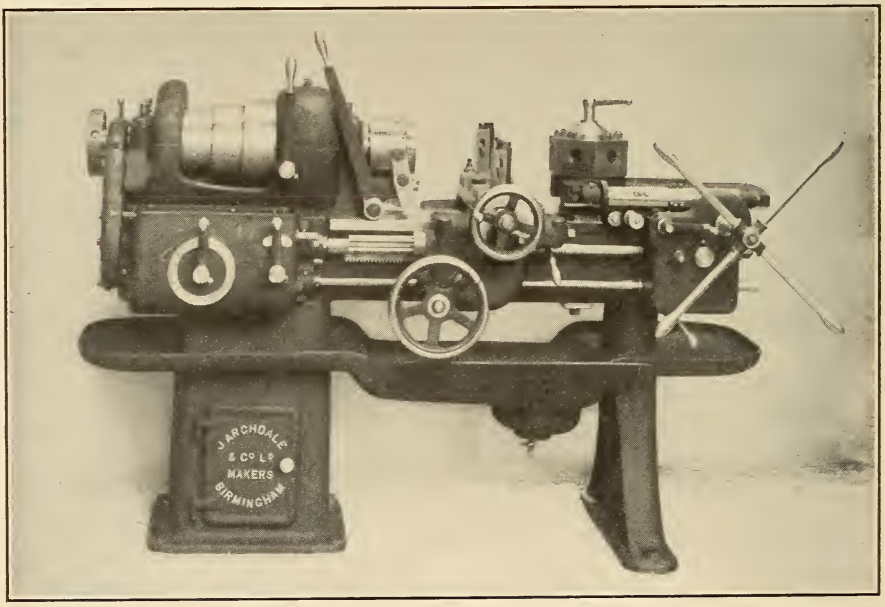


FIG 1.—HIGH-SPEED CAPSTAN LATHE. MESSRS. J. ARCHDALE & CO., LTD., BIRMINGHAM

clutches, others spring keys. A new kind of shaft or spindle is another result, that having keys planed solidly with the shaft (castellated shafts); and for doing this a special machine has been designed. Further, the problem of lubrication becomes increasingly important. The rigidity of the boxes, which carry so many gears and shafts rotating at high speeds, cannot be lightly dealt with in designing.

Though this is perhaps the most striking illustration of the kind—it is certainly the most familiar one—it is not more exceptional than others which are less apparent. There is hardly any machine operating cutting tools which has not been remodeled by the introduction of the new steels, some more extensively than others, but nearly all in a greater or less degree. The change is most apparent after the lathe in the drill-

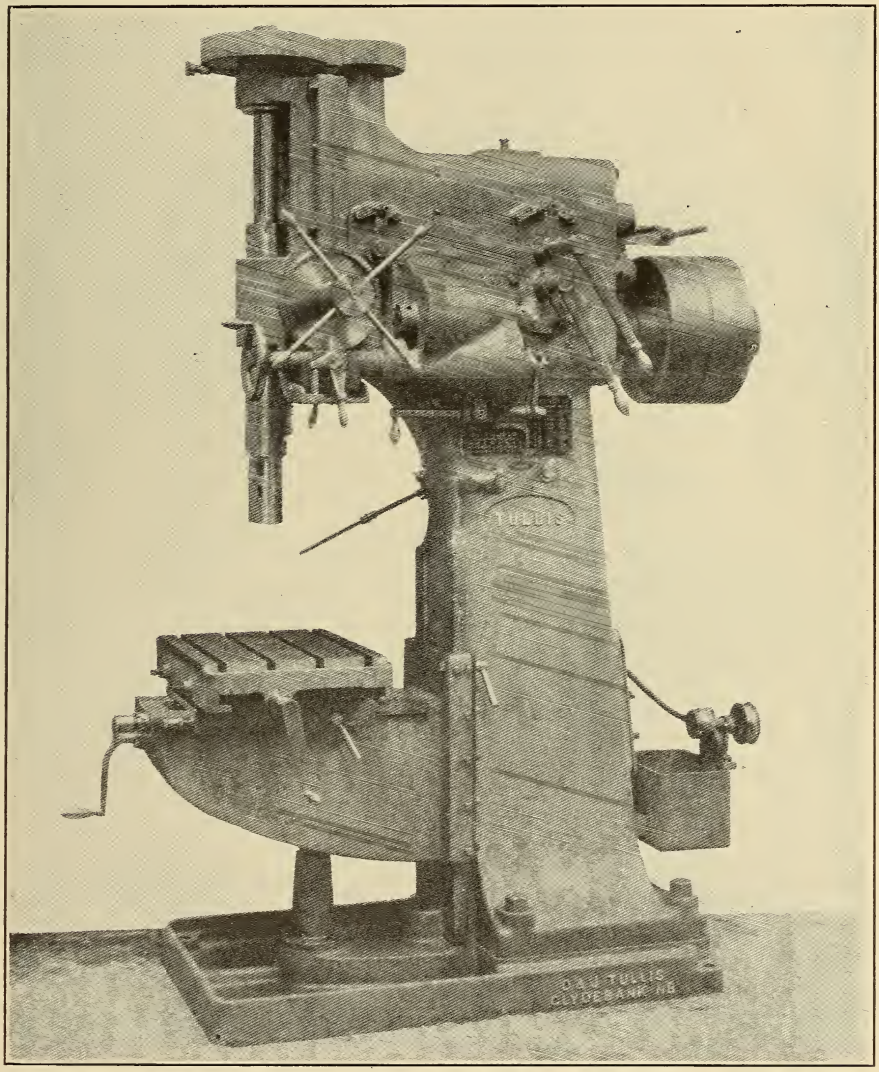


FIG. 2.—HIGH-SPEED VERTICAL DRILLING, BORING AND TAPPING MACHINE. MESSRS. D. & J. TULLIS, LTD., CLYDEBANK, N. B.

ing machines and boring machines and gear-cutting machines, and in cold saws with teeth of high-speed steel. The illustrations following will illustrate some of these and other facts.

The numerous machines which perform the operations of drilling, boring and tapping (often including facing and milling) have been long-

which control and indicate the speed or the feed changes.

Some good recent examples of this class are afforded by figures following. In the series of vertical machines built by Messrs. D. & J. Tullis, Ltd., of Clydebank, N. B., one of which is shown by Fig. 2, the driving is done by pulleys, fast and loose, requiring no countershaft. A motor

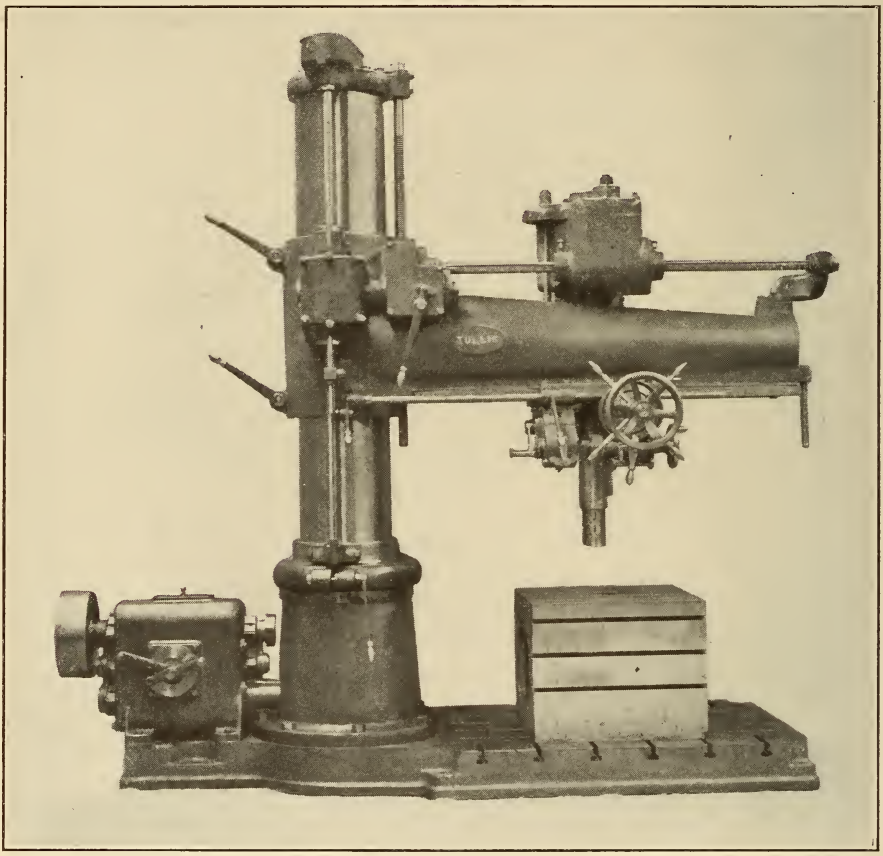


FIG. 3.—HIGH-SPEED RADIAL DRILLING, BORING AND TAPPING MACHINE. MESSRS. D. & J. TULLIS, LTD.

established favourites. We note recent developments in these which have come in response to high-speed work. In essential build and in scope of operations the machine types are familiar. But novelty lies in the substitution of gears for stepped cones, with their boxing in, which is all that is visible, and the levers and locking holes and pins

can be substituted for the pulley, as is a usual alternative offered by several firms. The pulleys in this example run constantly at 500 revolutions per minute and drive through a gear box, in which by the two hand levers seen, nine changes of spindle speed are obtained. A speed plate shows the different changes which correspond with the various

positions in which the levers are locked. These gears are of steel, case-hardened and run in oil.

The feed changes are not taken from the spindle, as in the old style, but from the pulley shaft, and are effected through gears instead of by cones. The conical boxes which enclose these gears are alone seen in the photograph. Six changes are obtained thus, ranging from 1-inch to 8-inch feed of the spindle per minute, a striking illustration of the slogging character of high-speed work. The balanced spindle of 2½-inch diameter, has a traverse of 15 inches, and can be stopped, started and reversed by a single lever.

Another example of recent modifications made in response to the demands of high-speed work is well illustrated by the radial drilling, boring and tapping machine (Fig. 3) by the same firm. After the motor and all-geared drives, the feature which would attract most attention is the section of the radial arm. This is in strong contrast to the nearly flat section practically universal on the old machines, or the approximately hemispherical section of later ones. Its section is doubly hemispherical

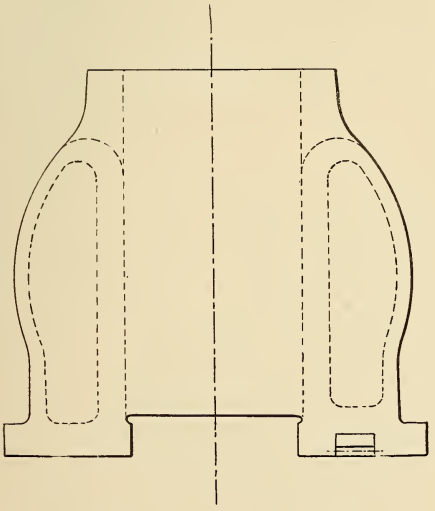


FIG. 4.—DOUBLE-PIPE SECTION OF RADIAL ARM OF DRILLING MACHINE, GIVING CENTRAL THRUST. MESSRS. D. & J. TULLIS, LTD.

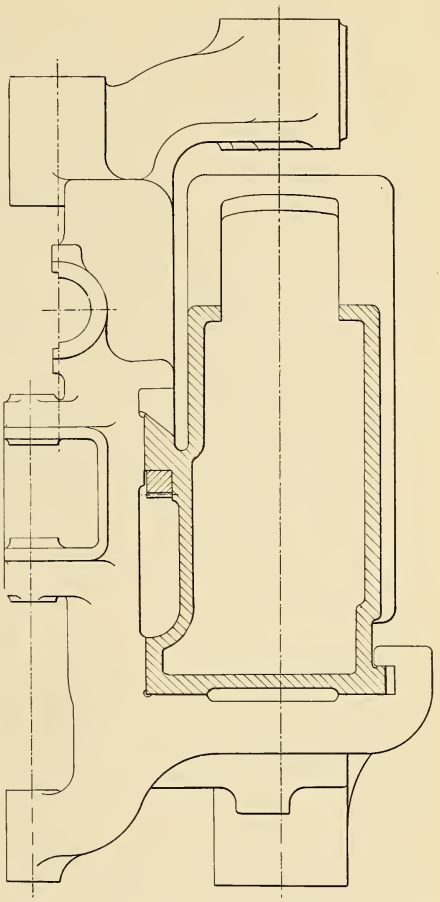


FIG. 5.—SECTION OF RADIAL ARM OF DRILLING MACHINE, GIVING CENTRAL THRUST. MESSRS. SELSON ENGINEERING CO., LTD., LONDON

(termed a double pipe) (Fig. 4), leaving a space between, through which the vertical spindle passes, the saddle fitting on the under faces of the arm, so giving a perfectly square thrust which does not tend to twist the arm as with the side-set spindle. One is reminded of certain recent discussions relative to the desirability of substituting a lathe bed of circular cross-section for the standard double girder section of lathe bed. We might discern in this the analogy to such a bed inverted. The lower face of the radial arm corresponds to the lathe bed inverted, the saddle being gibbed to the square edges.

The driving is done from a single

pulley, 16 inches diameter, taking a 5-inch belt direct from the main line shaft, and making 480 revolutions per minute. Through the steel gears in the box adjacent, operated by the two levers seen, nine changes of speed are provided, which are doubled at the saddle. These eighteen changes range from 19 to 375 revolutions per minute. The spindle has six rates of feed, also by gears in a box on the saddle; these provide from 24 to 120 cuts per inch. The spindle, 3 inches diameter, has a traverse of 15 inches. It is counterbalanced to return when the feed is released. As in practically all high-class machines, ball-thrust bearings receive the thrust of drilling. There is a reverse motion for tapping.

Messrs. The Selson Engineering Company, Ltd., of London, whose works are situated at Coventry, employ the form of central thrust arm shown by the sketch (Fig. 5), in which the arm is of deep rectangu-

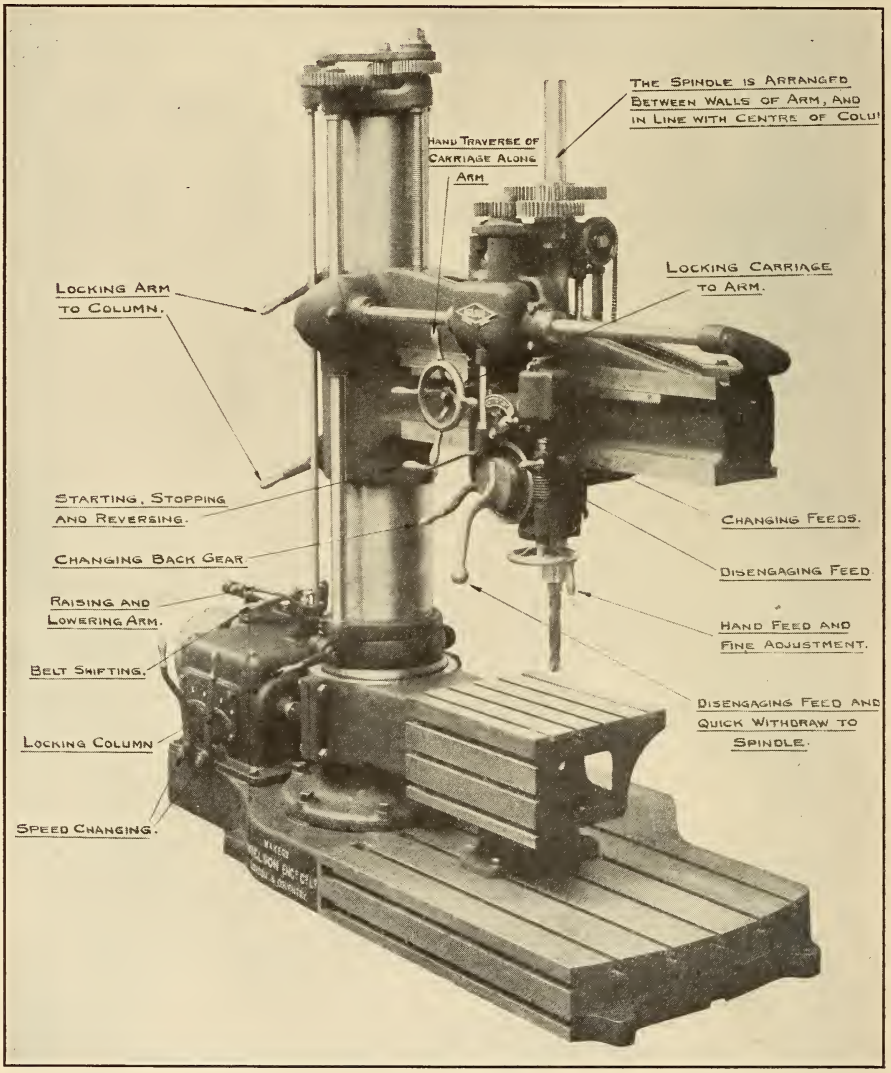

THE SPINDLE IS ARRANGED BETWEEN WALLS OF ARM, AND IN LINE WITH CENTRE OF COLU
HAND TRAVERSE OF CARRIAGE ALONG ARM
LOCKING CARRIAGE TO ARM.
LOCKING ARM TO COLUMN.
STARTING, STOPPING AND REVERSING.
CHANGING BACK GEAR
CHANGING FEEDS.
DISENGAGING FEED
RAISING AND LOWERING ARM.
HAND FEED AND FINE ADJUSTMENT.
BELT SHIFTING.
DISENGAGING FEED AND QUICK WITHDRAW TO SPINDLE.
LOCKING COLUMN
SPEED CHANGING.

FIG. 6.—CENTRAL THRUST RADIAL DRILLING MACHINE. MESSRS. SELSON ENGR. CO., LTD., LONDON

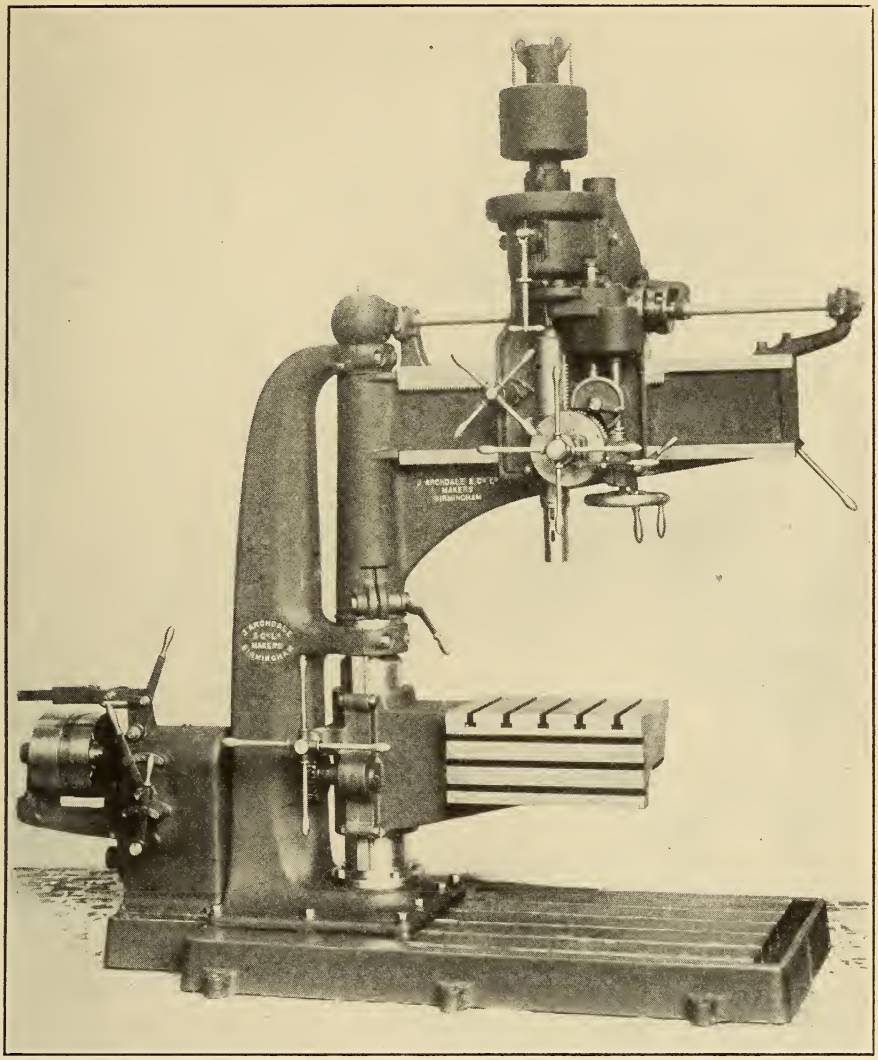


FIG. 7.—HIGH-SPEED RADIAL DRILLING MACHINE. MESSRS. JAMES ARCHDALE & CO., LTD., BIRMINGHAM

lar box section and the saddle fits on and is gibbed to the front and underside, the vertical thrust coming against the underside. The space between the walls of the arm is only wide enough to admit the spindle. The object in gibbing the saddle up at one side as well as underneath is to provide greater rigidity to the top spindle bearing and lessen the risk of vibration. The photograph (Fig. 6) shows the general appearance of the machine, with its single-speed pulley and gear box on the base-plate for the spindle speeds, and the feed-gear box mounted directly on the saddle. The spindle balance weight is necessarily brought outside and slides up and down a steady rod, being coupled to the spindle by a pitch chain. There are sixteen spindle speeds, and either four or six feeds, according to the size of machine. A ball thrust is fitted both to the drilling spindle, and to the column to facilitate its turning.

Another example of a high-speed radial drilling machine, driven by a constant-speed belt, in conjunction with a gear box on the baseplate, is seen in Fig. 7. It has eighteen spindle speeds, ranging from 520 to 21 revolutions per minute. Anti-friction devices are liberally supplied, the machine being exceptional in this respect; the radial arm swings on roller bearings, the spindle has ball-thrust bearings, and the saddle also runs on rollers on the square edges of the arm. The saddle is locked by a tapered key thrust endwise by a handle and rack and pinion, so that a firm clamping action is secured. The spindle, which is set as closely as possible to the face of the arm, is driven through a friction clutch, which can be reversed when running at its highest speed, and it is balanced by a weight encircling the top casing, as seen. The four-spindle feeds are obtained through gears mounted on the saddle and range from 47 to 160 revolutions per inch. A vertical traverse of 12 inches is provided for, and the maximum drilling capacity is 2½ inches. This is by Messrs. James Archdale & Co., Ltd., of Birmingham.

In the horizontal drilling, boring and tapping machines we meet with the same kind of developments which are so noticeable in those with vertical spindles. Stiffened framings, better designed to resist increased stresses, higher driving power by single-belt pulley or by motor, gear boxes fitted in place of stepped cones, anti-friction races, larger ranges in speeds in well-graded advances, the abolition of the countershaft, narrow guiding ways, etc.

The horizontal drilling and tapping machine (Fig. 8), by Messrs. D. & J. Tullis, Ltd., has its column built with the pipe section already noted on the radial machine, with guide ways on the front face to receive the saddle, a section which is admirably calculated to withstand the torsional stresses set up by high-speed work

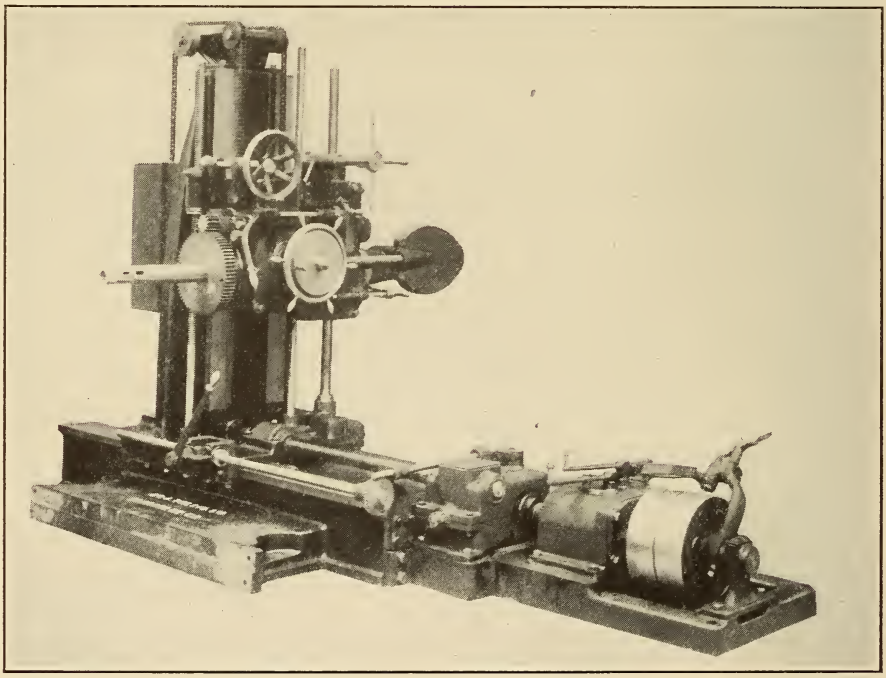


FIG. 8.—HORIZONTAL DRILLING AND TAPPING MACHINE. MESSRS. D. & S. TULLIS, LTD.

and heavy duty. The column fits on the horizontal bed by a narrow guiding way, being gibbed to the two vertical edges *a, a* (Fig. 9), with a take-up strip on the inner edge, while at the edge of the other way there is a clearance. Gib plates underneath each lip prevent lifting. The column is traversed through a handwheel carried in the saddle turning a worm wheel and rack pinion. A quick-power adjustment is also fitted. The saddle which moves on the column also has the taper-strip adjustment and a vertical hand traverse. The

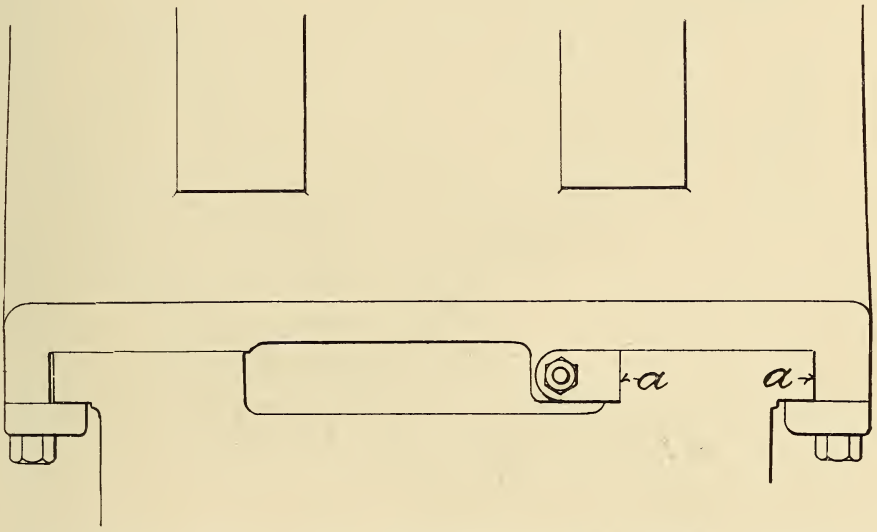


FIG. 9.—FITTING OF COLUMN TO HORIZONTAL BED OF DRILLING MACHINE. MESSRS. D. & J. TULLIS, LTD.

spindle, 2½ inches diameter, has 15 inches of traverse. It is driven from the pulleys at the right, 14 inches diameter, taking a 4-inch belt and turning at 400 revolutions per minute. Thence the drive goes through the gear box, providing eight changes, which, with a double gear on the saddle, gives a total of twelve speeds, ranging from 20 to 400 revolutions per minute. Three power feeds of 60, 90 and 120 cuts per inch are arranged for the spindle, and it has a quick hand traverse. A ball thrust takes the end pressure.

The developments in milling machines are strikingly exemplified by the numerous designs which are radically different from their predecessors of only some seven or eight years ago, and many of the new features are not very readily apparent, notably the general move in the direction of increased knee strength. The closed-box form has been adopted by a number of firms in place of the older open-webbed type, while tables and slides have been increased in thickness and strength. Another very important factor, tending to the same end-increased rigidity, is favoured by the adoption of the all-geared drive, which permits of carrying the metal of the framing right up the sides to the top, making a closed box instead of the pierced and weakened framing employed with step-cone drives. Some of these features are seen in the machine by Messrs. D. & J. Tullis, Ltd. (Fig. 10). This has but one pulley for driving (or a motor may be substituted), and both speeds and feeds are changed through gears enclosed in boxes, and the feed changes are driven directly from the pulley shaft instead of from the main spindle.

The relation of speeds and feeds is a subject which is of vital moment

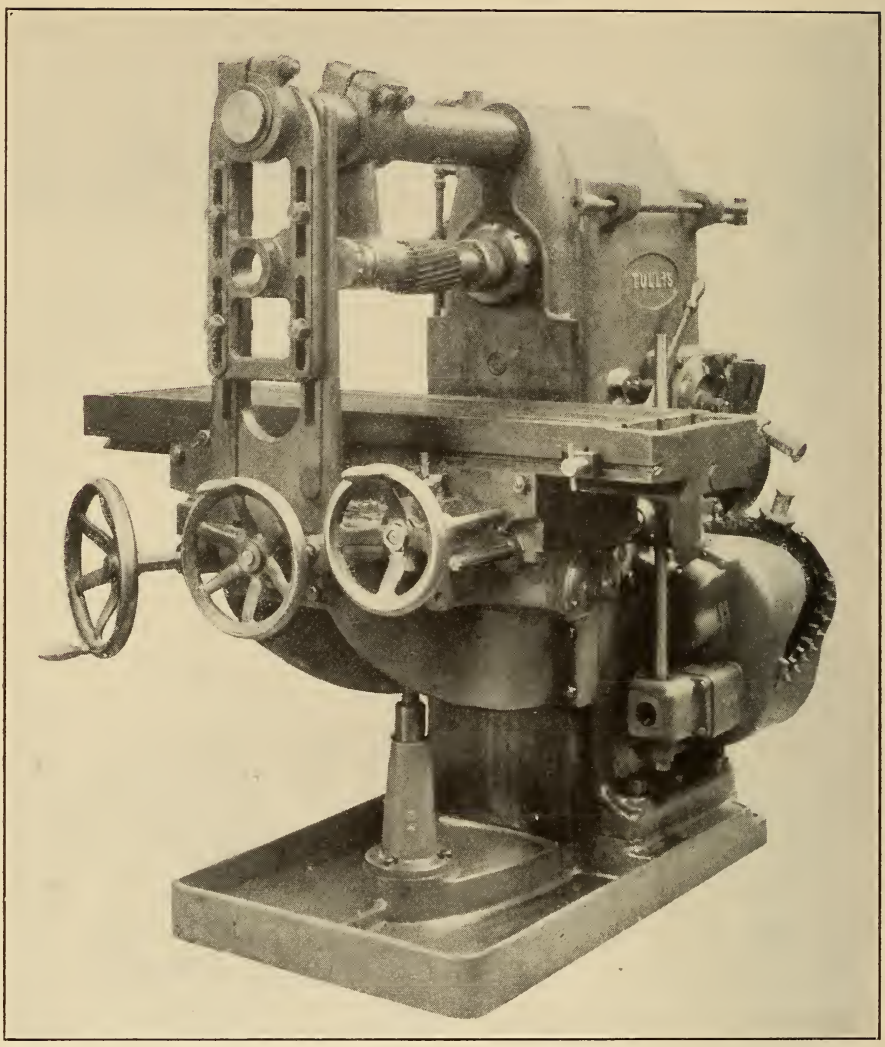


FIG. 10.—PLAIN HORIZONTAL MILLING MACHINE. MESSRS. D. & J. TULLIS, LTD., CLYDEBANK, N. B.

in the operation of machines. In the old milling machines the feeds were derived through and from the speeds, varying with the latter, so that a high-speed meant a rapid feed and vice versa, which is an unmechanical relation. Later practice has realized that each should be independent of the other and, therefore, driven independently. This is done now in large numbers of milling machines in which the change was first introduced, and it has been extended to other types.

In the machine illustrated, the driving pulley, 16 inches diameter, takes a five-inch belt, and, being driven from the main line shaft, the use of a countershaft is avoided. Thence sixteen spindle speeds are obtainable through the gears, ranging from 20 to 320 revolutions per minute. The gears are of steel, hardened, and are controlled by two levers, one giving eight speed changes, the other changes any one between fast and slow. As the gears are of the nest type, only those

which are doing work are in mesh. The feed gears, also of steel, provide sixteen changes, from 1 inch to 16 inches per minute, operating either way. These are changed by a single handle.

The interior of the milling-cutter spindle is case-hardened, and three interchangeable cutter-arbor supports are provided with the bracing. In the screw feed to the table the phosphor-bronze nut is revolved instead of the screw, a practice which it may be noted has been adopted for some time past in the lead screws of some heavy lathes. The knee is of boxed form, webbed inside, and has a long bearing on the pillar extending above the face of the knee in order to lessen the tendency of the knee to tilt under heavy pressure. The pump for lubrication is behind the column and is driven off the end of the feed shaft, a roller valve being provided for use when the lubricant is not required. To prevent the flooding of lubricant over the table when cuttings choke the discharge a pipe connection is provided to the tank between the two end walls. The lubricant returns to the tank through flexible tubing.

Heavy boring machines have shared in the advances which have influenced the designs of other machine tools. The old slight designs, with stepped cones and slender boring bars, have nearly disappeared. The multiplication of spindles is also carried out to a greater extent of late years, machines with two, three, four or more spindles being very common. These are either constructed in the snout design, in which the boring spindle is supported in a snout bearing sufficiently stiff to enable it to do its work when carried thus, or an outboard support is provided for the longer bars which are driven from the heads. Usually, though not always, the second design is necessary when bars of small diameter may have to be used—that is, the snout bearing is too large in diameter to enter the work. For the heaviest cylinders vertical boring is preferable and more convenient, but for all

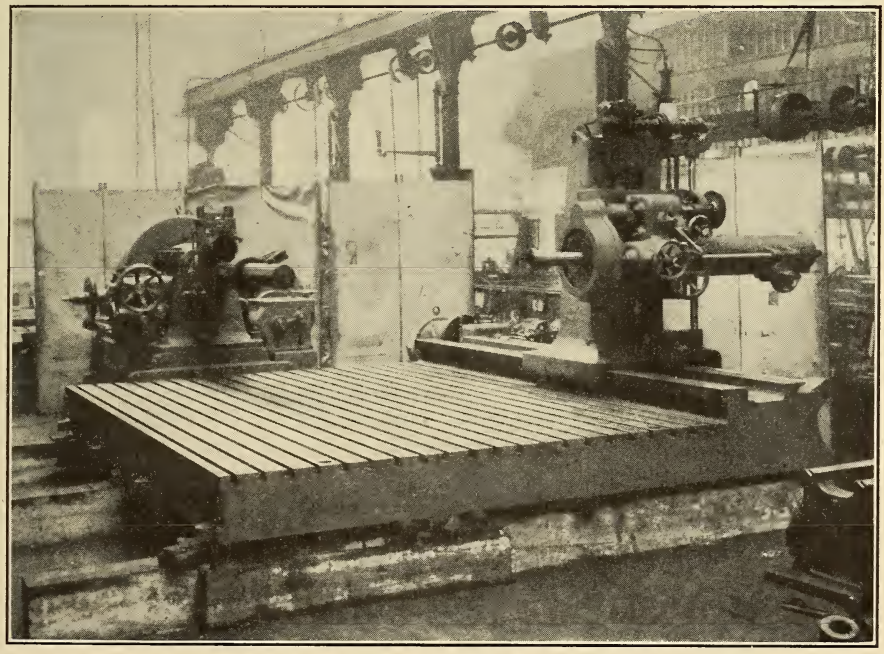


FIG. 11.—DOUBLE-HEADED BORING MACHINE. MESSRS. TANGYES, LTD., BIRMINGHAM

ordinary kinds of work, such as the smaller steam cylinders, pump cylinders, motor cylinders and other objects, the horizontal position is more suitable. The centres of the boring heads may be fixed for repetition work, or they are adjustable within a moderate range. They are included in a self-contained machine, each spindle being actuated by the same driving mechanism.

A double-headed horizontal boring machine (Fig. 11), having independent heads suggestive of floor-plate practice, is designed for boring without resetting engine beds and similar objects. One bar bores the cylinder, the other the bearings. Both bars are motor driven. One is 8 inches diameter, the other 4 inches. Each has its own range of speeds through its variable-speed motor driving through gearing, and each has eight feeds, reversible. Horizontal and vertical adjustments are provided, and also facing arms for each, of the star-wheel type. The working surface of the tee-grooved base measures 16 feet by 11 feet 4½ inches. This tool is by Messrs. Tangyes, Ltd., of Birmingham.

The effects of the growth of massive work, with its results in vastly heavier machine tools, are not yet all accomplished. Among the later and less noticed issues are the substitution of light, portable machine tools for the extremely heavy fixed types. The advantage gained is not only that of less cost of the machines, but also that of the greatly reduced amount of handling and resetting of large castings and forgings, and plated work in course of erection, to present them in different positions to a fixed machine and to different machines. The size and nature of the work and the class of tooling to be done may determine whether the work will be better done with a portable tool attached directly to the casting or forging, or whether a floor plate shall be employed and the machines be ranged round and adjusted thereon. Speaking generally the floor plate is more convenient, especially if the operations are much varied and accuracy is of great importance. An intermediate stage in design is that in which heavy machines are designed to perform an increasing number of diverse operations in order to avoid shifting the work, such as drilling, boring, tapping, and facing, drilling and milling, planing and milling, planing and drilling, and also performing these operations on more than one face simultaneously and at right or at other angles. But the separate light machines, each doing either planing, drilling, tapping, milling, key-seating, etc., on heavy castings, forgings, or structures, are usually more favoured; and the floor-plate arrangement is adopted in all shops dealing with a regular run of massive work, whether it be machine tools, engines, electrical or other machinery. Usually the floor plate receives the portable machines upon its surface, but in some cases they may be attached to the piece of work itself.

A concession to the requirements of the heavy classes of work is illustrated by the portable horizontal drilling and milling machine (Fig. 12). It can be lifted by the eye bolts at the top of the column and set down anywhere to suit work which is too massive to be moved, or which has been packed up and adjusted correctly upon the floor plate. The column can be adjusted longitudinally along the bed (on which it fits with a narrow guide) by means of a screw and hand wheel. The spindle is driven from a variable-speed motor of 3½ brake-horse-power at the top of the column, having a three to one range of speeds. Thence all movements are effected through gears. The feeds are imparted to the saddle and the column, giving 75 cuts per inch in each direction. The spindle, 2¼ inches diameter, can be swiveled through 25 degrees in each direction, and has 15 inches of adjustment through the sleeve by which it is driven. The saddle has a verti-

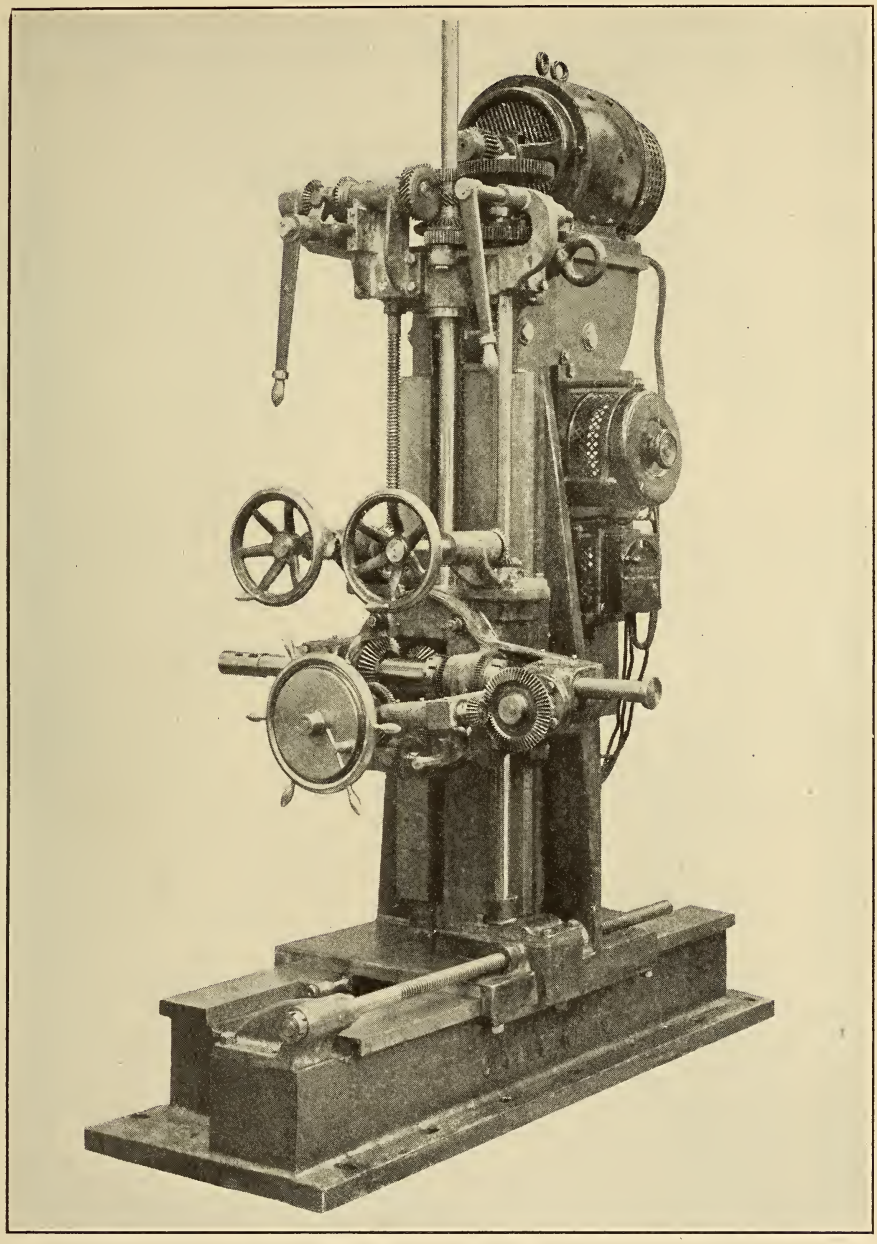


FIG. 12.—PORTABLE HORIZONTAL DRILLING MACHINE. MESSRS. D. & J. TULLIS, LTD.

cal movement of 3 feet up and down the column. This machine is another example of Messrs. D. & J. Tullis, Ltd.

Those who recall the light turret lathes of a few years since, and have noted the development of heavy types, find much food for reflection. From dealing with small bar work they have taken up the tooling of very heavy castings and forgings. The heavy turret lathe has thus be-

come an indispensable portion of the equipment of the up-to-date machine shop, notwithstanding that only some half-dozen years ago its employment in general engineers' works was very limited indeed. As in the common lathes, the relations of variable speeds obtained by stepped belt cones has long been unsatisfactory, because, in the old designs, no such thing as a regular range or gradations of speeds was attempted. It is impossible to say on what principle they were designed. The smallest step was of small diameter to obtain the highest speed, and the different steps might or might not be fairly regular; generally they were not. But there was always a big jump to the back gear, a large gap between any one step with back gear in and out. Moreover, the smaller steps were utterly useless if high-speed tools are to be utilized to their utmost. At present, therefore, the steps in the best lathes, when such are retained, whether back gear is in or out, all advance in some very regular and definite geometrical ratio.

A heavy turret lathe of the all-geared head class, by Messrs. Tangyes, Ltd., is shown by Fig. 13. It weighs over 7 tons, and is of 18 inch centres (36 inches swing). A single-belt pulley drives the all-geared headstock spindle, with a range of sixteen speeds, from 340 to 5 revolutions per minute. The hole through the spindle will take 3-inch rough bar. The front bearing is 6 inches diameter by 7½ inches long. The hexagon turret measures 21 inches across the flats, and the square turret on the cross-slide 9 inches across. The hexagon turret rotates on ball bearings. The usual arrangement of stops, trips and lubrication devices is included.

We may now consider briefly the second kind of influence mentioned. Machines may develop novel modifications at periods when the force of circumstances produces a general demand for improved designs. It results from persistent objections made to the faults found to be inherent in existing machines. A few observations may be offered bearing on some of these developments. They must needs be of an eclectic character, because the field cannot be covered in the space afforded.

Gear-cutting and the machines designed for accomplishing it is now a vast industry. The methods of the old horologists long dominated those which were afterwards adopted by the engineers, even when the milling cutters had taken the place of the fly cutter. Only recently has the tyranny of the single rotary cutter been partly broken by the inrush of new machines designed for producing teeth either by form-planing or by generating. Each idea is somewhat old, but the successful machines are comparatively recent. At short intervals some new machine is offered which is more than a mere modification of a pre-existing design, notwithstanding that its general outlines may suggest a prototype. The form-planer designs and the generating machines, including the hobbers, are now ubiquitous. The single rotary cutter machines have been so highly developed that it seems that the last word must have been said about them. It is difficult to see how they can be made more efficient or more accurate, because the possible multiplication of cutters which might be suggested introduces difficulties due to heating and other questions. In any case the rotary cutters do not fulfill the perfect ideal of the mechanician even for spurs, and very much less so for bevels.

As the types of gears are so varied, the old machines which were designed for cutting the whole range of spurs, racks, bevels, worms and spiral gears are being gradually and rapidly displaced by those which are specialized for cutting one class of gears only in the most accurate and efficient manner. And round these independent types numbers of satellite machines have arisen for turning and boring or milling blanks, for

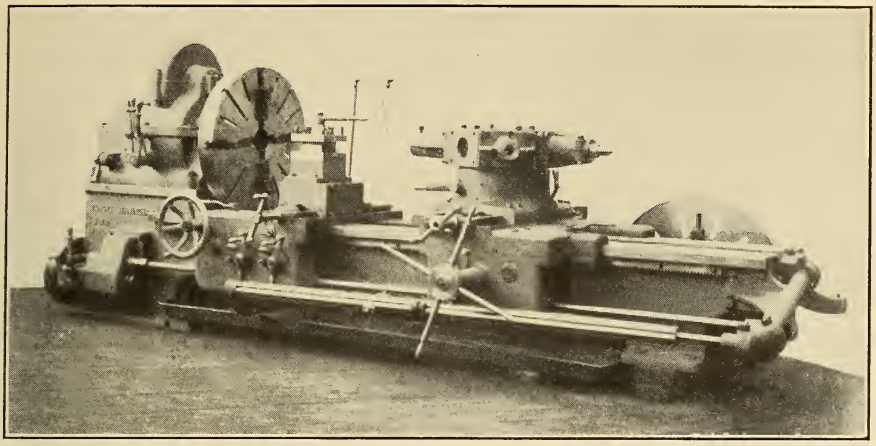


FIG. 13.—ALL-GEARED TURRET LATHE. MESSRS. D. & J. TULLIS, LTD., CLYDEBANK, N. B.

rounding teeth, for grinding hardened teeth, until the gear cutters and the methods of their manufacture have become a very big department in the machine shop and given rise to the extension of many firms who produce cut gears for the trade.

The planing machines of the past, the designs of which were stereotyped for a couple of generations, afford another notable instance of improvements effected. The first changes made lay in the acceleration of the return stroke from two or two and a half to one, up to four or six to one. But though this saves time, it does not in itself make for high efficiency, inasmuch as the cutting rate may be slow. But if this is speeded up, then, though the ratio of return may figure less, the efficiency may be high. Moreover, a high rate, either of return or of cutting, involves a higher momentum with a corresponding increased shock on reversal. Hence recent planer design has advanced in four directions in the following order: First, in employing double-cutting tool boxes; second, in increased cutting capacity; third, in absorbing and utilizing the momentum at reversal; fourth, though to but a limited extent, in a radical change in design in which the travel is imparted to the tool instead of to the work table.

These planer developments began in earnest when the milling machines began to seriously menace the long-established position held by the planers, and were spurred on further by the introduction of high-speed tools, which during the last decade have had the result of evolving a number of new planer designs and radical improvements in driving. But for these improvements the planing machines might have occupied a much lower status than they do to-day, though now, notwithstanding the increase in milling practice, planing seems to be nearly as popular as ever.

The sensitive drilling machines again afford remarkable examples of this same variation and specialization. Machinists now know how terribly inefficient the old machines were. Heavily built geared machines were long used for drilling small as well as large holes. The belt-driven sensitive machines without gears, now so familiar, were novelties in a great many shops ten or twelve years since. The sensitive high-speed design of drilling machine has until recently been confined to those of small dimensions and very light, with fixed heads. Recently the principle has been applied to light radials. The development of these appears to have been due in the first instance to the

requirements of motor manufacturers and electrical engineers, for such drilling as that in framings, gear cases, cylinders and various bulky castings and partly assembled mechanisms, which are too large to go under an ordinary sensitive machine, and must either be done under an ordinary radial, or more slowly by small, portable electric or pneumatic drills. These were used formerly to a probably greater extent for the various small holes and counter sinking in the class of work mentioned above, but the sensitive radial provides in most cases a more rapid and easy means of drilling in quantity.

Fig. 14 represents a good example of the sensitive radial machine, by Messrs. D. & J. Tullis, Ltd., from which the principal features may be gathered more fully than from a photograph. The table, which is adapted for holding work upon its top or side face, has a stout cylindrical pillar bolted to it, upon which the socket of the radial arm fits and rotates upon a ball race, being clamped by the handle and split lug. The drill spindle saddle travels along the arm when the large star handle to the left is rotated; and it fits by a narrow guiding way on the top edge of which the taper gib strip is fitted.

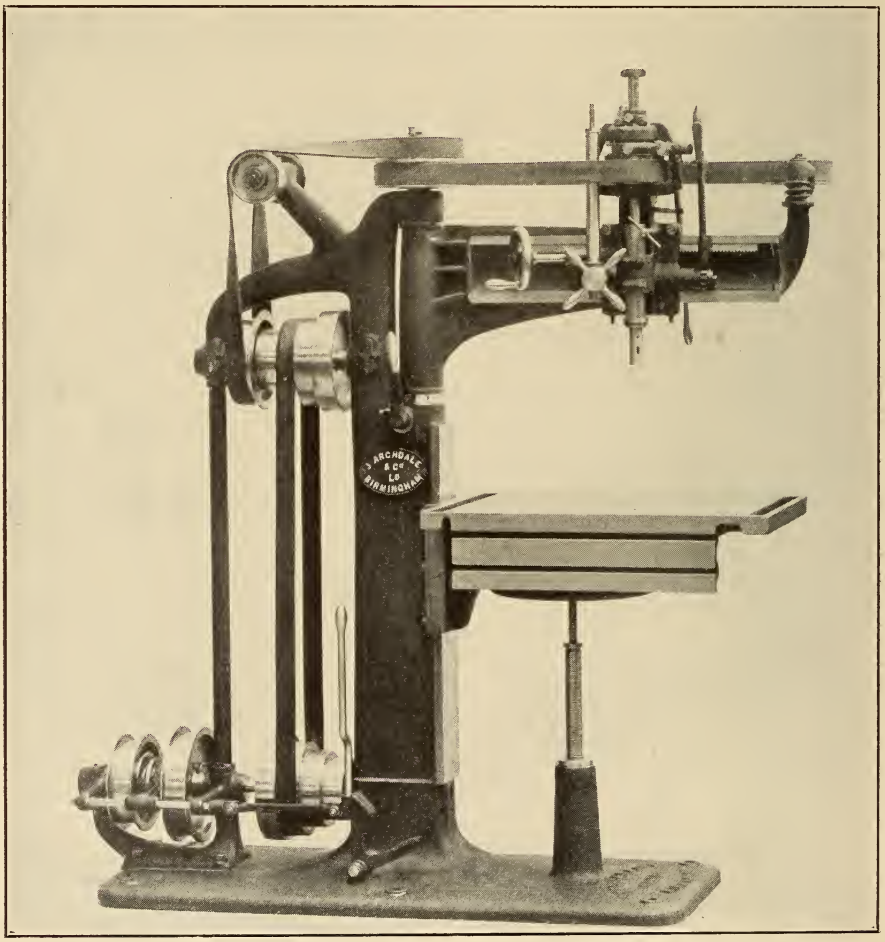


FIG. 15.—HIGH-SPEED COMBINED SENSITIVE AND RADIAL DRILLING MACHINE. MESSRS. JAMES ARCHDALE & CO., LTD., BIRMINGHAM

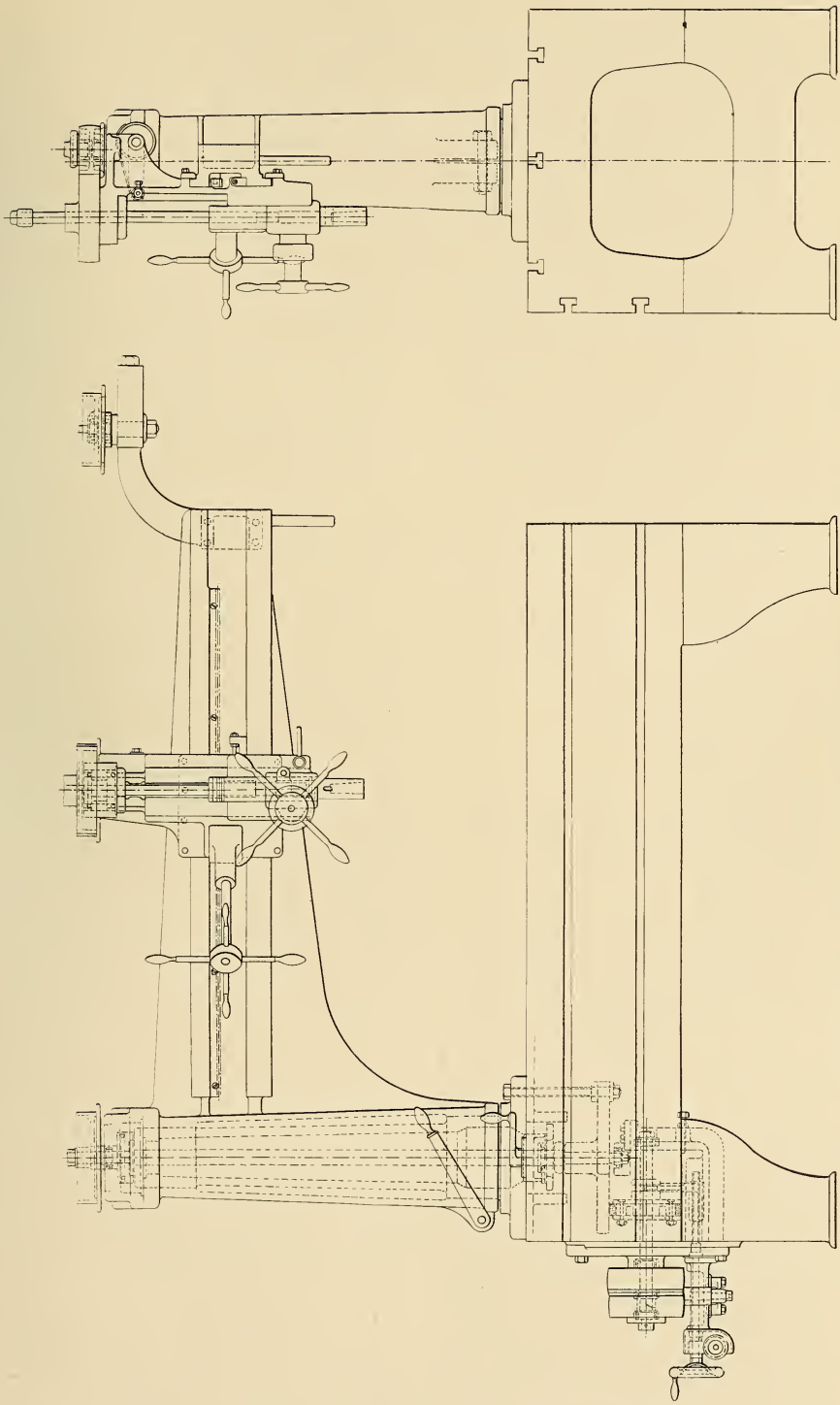


FIG. 14.—HIGH-SPEED SENSITIVE RADIAL DRILLING MACHINE. MESSRS. D. & J. TULLIS, LTD.

A vertical adjustment of 8 inches is given to the short slide which moves on the face of the saddle, and the spindle sleeve with its rack has a traverse of 4 inches inside this slide. A ball thrust is provided to the spindle, and the spring-balancing mechism is arranged to raise the spindle to the top when the feed handle is released.

The spindle is driven in the first place from the constant-speed pulley at the end of the table, this being 7½ inches in diameter by 2 inches wide, and making 900 revolutions per minute. Thence a horizontal shaft and friction disc convey the drive to the central vertical shaft inside the pillar, the speed being varied by turning the small hand wheel seen close to the pulleys, which feeds the disc across the face of a bowl attached to the bottom of the vertical shaft, the speeds being shown on the dial close to the hand wheel. They vary from 600 to 1,100 revolutions per minute. A lever-operated brake stops the spindle quickly if desired, when the belt is thrown over the loose pulley. From the top of the vertical shaft an endless belt passes along around the idler pulleys and the spindle pulley (these being mounted on ball bearings).

This machine is built with maximum spindle radii of either 3 feet, 4 feet, or 5 feet, all with a maximum distance of 23 inches from the spindle nose to the table face, and holes up to ¾ inches diameter can be drilled.

An example of a machine designed in response to the same class of requirements is seen in Fig. 15, a sensitive radial drill, with reversing gear for tapping, built by Messrs. James Archdale & Co., Ltd., of Birmingham. In this case the radial arm swings on a tall column, with ball bearings, and the table is not of the box form, but fits against the face of this column, with an elevating motion by hand wheel and screw. There is, therefore, no need for a supplementary slide on the spindle saddle, and the downward movement of the spindle (5 inches in amount) is only that given by the star handle, or alternatively for more sensitive feeding by the lever to the right. When tapping is being done, the spindle may be instantly reversed by a hand lever operating friction clutches on the spindle. The latter has a ball thrust. The driving is done from a two-speed countershaft on the base of the machine, comprising two pulleys operated by friction clutches, so that no change of belt is necessary. The arrangement permits of changing the speed instantly from drilling to tapping. A 3 horse-power variable-speed motor can be substituted for the countershaft pulleys. With the employment of the four-speed cones eight spindle speeds are produced, ranging from 130 to 1,500 revolutions per minute, and holes up to 1 inch diameter can be drilled, and ⅝-inch holes be tapped in cast iron. It may be mentioned that the spindle saddle runs on rollers on the top rail of the arm, as is the practice with so many of the firm's drilling machines and with profiling machines.

Another fact which was not fully realized for a long while was that a drill spindle need not necessarily be operated vertically. Instead, therefore, of up-ending long pipes, columns, cylinders, etc., under a vertical drilling machine, the practice is increasing of building special horizontal types for dealing with this kind of work when laid horizontally. And as usual in purely drilling operations the depth of metal is limited to the thickness of a flange or foot, the traverse necessary is but small, and the design may be simple and far less cumbrous than a vertical machine. In double machines also both ends of the work can be drilled at once—an impossibility with vertical machines.

The capabilities of the multiple drilling device, again, were not fully recognized until long after multiple-spindle machines came into use for boiler and girder work. Linear ad-

justments alone for varying centres were made for a long time, the principal uses of the machines being, in the case of two-spindle drills, for locomotive rods. Then variations in diameters, as well as in centres, followed in machines for drilling holes in the flanges of pipes and cylinders and for valve work. These have become established largely now in many shops, both in vertical and in horizontal spindle designs. Another class of machines has also been developed extensively during the last five or six years—that of the type with two, three, or four or more spindles adjustable along a rail over the long table, so that they can be used either for repetition work at fixed centres or be adjusted irregularly, or be used independently, so that the operator may be setting one piece of work while a drill is going through another piece alongside.

One of the results arising from the introduction of high-speed steel has been that the old slow methods of fixing and readjusting pieces of work which involve angular relations have become intolerable. So long as machine operations occupied a considerable proportion of the total day's work this fact was not so glaringly apparent, but now that the time of cutting has been reduced to such a remarkable extent the period occupied in fixing and changing reveals itself as obviously out of proportion. This is particularly the case with drilling operations, when holes have to be put in at several different angles. In much of this work the actual running time of the machine constitutes only a small percentage of

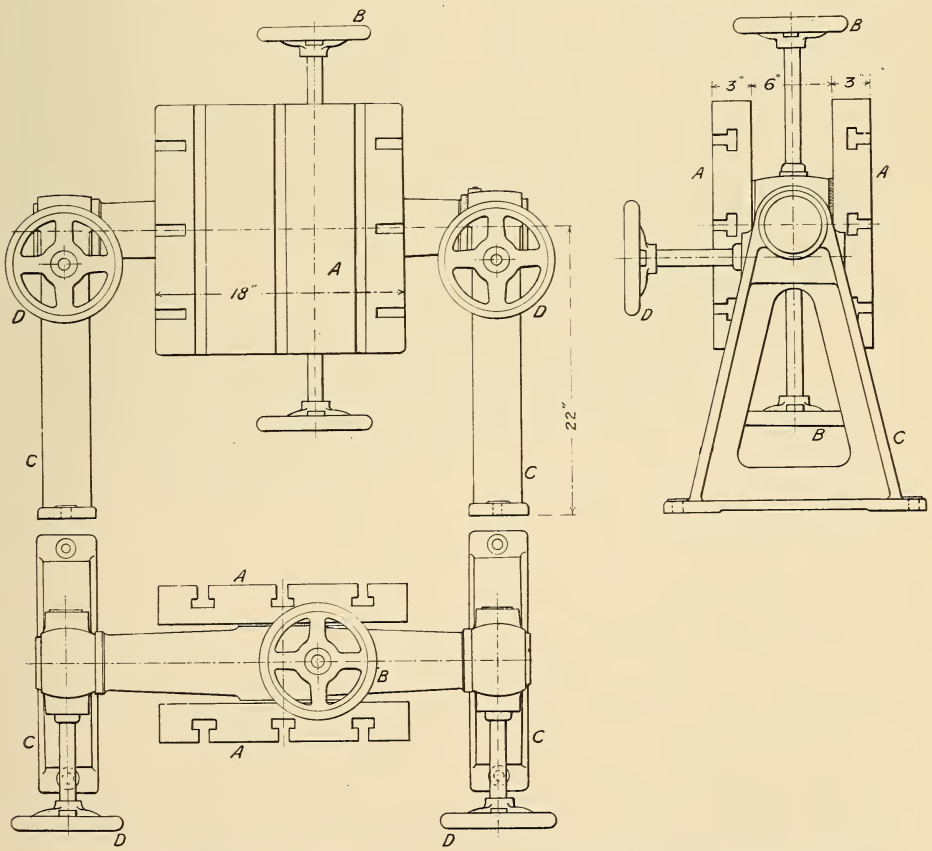


FIG. 16.—WOLFENSBERGER PATENT UNIVERSAL TABLE. MESSRS. WILLIAM ASQUITH, LTD., HALIFAX

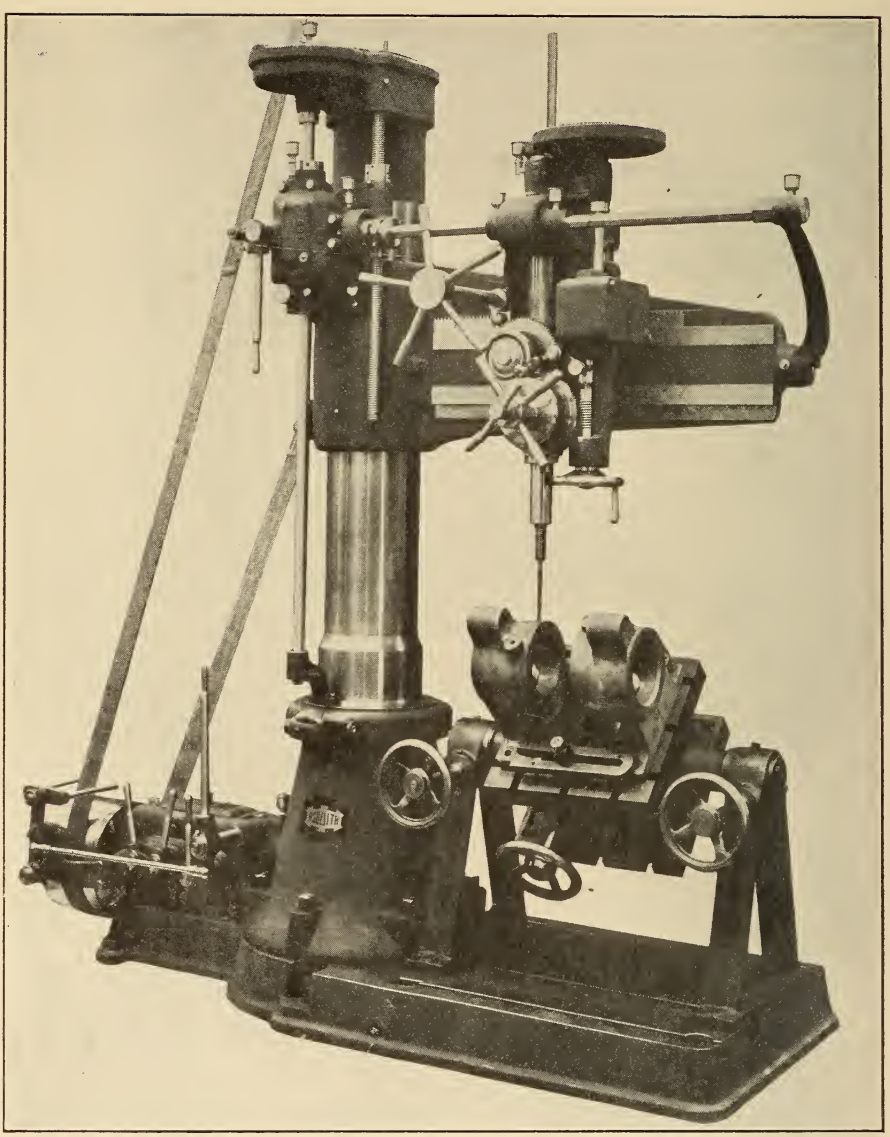


FIG. 17.—WOLFENSBERGER PATENT UNIVERSAL TABLE UNDER AN ASQUITH SMALL RADIAL DRILL. MESSRS. WILLIAM ASQUITH, LTD., HALIFAX

the working time. For this reason it is not surprising to find a good many methods being devised to shorten the time of fixing work and of changing it into various positions. Hence much more attention is given to the tables of radial drilling machines than formerly. Many are made to cant, to permit of doing work at an angle. The table can be canted by worm gear, and is sometimes arranged to swivel also in the other direction. Or a separate table is placed upon the base of the machine with double swivel movements.

One of the most useful contributions of this class is the Wolfensberger universal table, one of German origin, manufactured in Eng-

land by Messrs. William Asquith, Ltd. It has double swivel movements, so providing a universal range, and the construction is such that its action is balanced (a feature not found in ordinary swivel tables), and it is possible to set two pieces of work to be dealt with one after another.

The drawing, Fig. 16, shows in outline the construction of the table. There are two work-tables *A, A* of square shape, as shown, or alternatively circular. These rotate about a pivot, being turned by concealed worm gear, operated by either of the handwheels *B, B,* according to which happen to be in the more convenient position. The pivot turns in a stout axle, which rotates in bearings *C, C,* also through worm gear, actuated by the handwheels *D, D.* The work, bolted to the faces of tables *A, A,* may, therefore, be rotated through a complete circle in either direction, graduations on the shoulders adjacent to the meeting faces of each part indicating the amount of angling. If required, stops can be fitted for each ninety degrees of angle.

Balancing can be done by attaching a casting or forging of similar form to each table, or any mass of metal may be bolted to the opposite side to balance the weight of a single object being drilled. It will be observed that not only is time saved in setting, but that in the case of heavy work the driller is independent of further assistance from cranes or from helpers. For very heavy castings such as beds, these tables can be adjusted by an electric motor drive instead of the handwheel method used in the smaller tables. The photograph, Fig. 17, shows a table under an Asquith small radial, with a couple of bearings tilted for drilling holes at an angle. Tables of special form can be made for dealing with a run of repetition work, and the device is also of value for use when lining out work in different planes.

Grinding machines have been developed in response to the two kinds of requirements—that is, both in regard to improvements in construction and in respect of new classes of industries. The greater degree of accuracy now demanded of machined work has resulted in a much higher standard of workmanship in grinding machines and in their design and details, as, for example, the micrometer adjustments and the arrangements for protection and guarding of slides and spindles. With the advent of motor work an immense impetus has been given to the grinding machines and has led to their rapid adoption for other manufactures in place of the older and slower practice of lapping. The grinding of cylinders, crankshafts, pistons and other parts, internal and external, is now displacing a great amount of lathe work, and in many cases the lathe is not used at all, while in other instances it is employed in the roughing-out stages, and the accurate finishing is done by grinding alone. Improvements in materials for grinding wheels have simultaneously accompanied this remarkable progress in machines. Beginning with a few well-defined types, these have spread into many specialized and modified designs, either for doing a single class of grinding only or for a certain limited range, and it is impossible to foresee the position of grinding in relation to the other methods of the machine shop in the course of a few years. Even much work that was presumably only suitable for the milling machine—that is, certain flat objects—is now being rapidly appropriated by vertical grinder designs, which are able to deal with the work in a more rapid and accurate fashion.

Although this rapid survey deals with some of the more salient features of present-day machine tools, every machinist will understand that it can only touch lightly thereon, and much that is of interest must perforce be omitted.

THE MANHATTAN BRIDGE

By Howard R. Cummings

ONE of the most important among the vast number of great engineering structures recently built in New York City is the Manhattan Bridge. This crosses the East River about a quarter of a mile above the Brooklyn Bridge, and serves as another link to connect the two largest boroughs, Brooklyn and Manhattan, of New York City. It will afford relief for the excessive demands made on the Brooklyn Bridge, due to the extreme congestion of the passenger transportation lines between these boroughs. It includes some of the most advanced features of design, and the highest developed methods have been used for making the steel in the mills and erecting it at the site.

Plans for the Manhattan Bridge were started as early as 1898, but they have been contested between individuals, civic societies, engineers and architects. One contract was carried to the Appellate Division of the Supreme Court and declared illegal. The objections made by the court were eliminated and a new contract drawn, but again a temporary injunction was granted, and it was not until June 15, 1906, that the contract for the towers, cables and suspended structure was let.

New York City has never been able to keep up with the demands for transport facilities. When the Brooklyn Bridge was opened, on May 24, 1883, Brooklyn had a population of only 600,000. To-day it has a population of 1,600,000. Elevated railroads, as we know them, were not then in existence; nor was electricity used as a power for transportation. For six years pedestrians were charged a cent for crossing the bridge. Mr. John A. Roebling expected that the Brooklyn Bridge would carry less than ten million people per annum, but at present more than half a million cross the bridge every twenty-four hours. In 1898 the cable cars not being sufficient to accommodate the people crossing the bridge, many Brooklyn electric car lines were put on the roadways. As each roadway is only 18 feet wide, one readily sees the congestion caused by the ever-increasing vehicular traffic. The opening of the Manhattan Bridge has reduced this traffic one-half, has taken trucks away from the ferries, and besides has created a traffic of its own.

The Manhattan Bridge has eight single lines of track, four surface railway tracks on the upper deck and four elevated or subway tracks on the lower deck. The eight railway tracks will have a carrying capacity of 180,000 passengers per hour—more than double that of the Brooklyn Bridge. It has, in addition to the eight railway tracks, a roadway 35 feet wide in the clear and two sidewalks, each 12 feet wide. The total width of the bridge is 120 feet, and the total length, including approaches, 6,855 feet. The bridge extends from Canal street near the Bowery in Manhattan to Nassau street in Brooklyn. Each of the Manhattan and Brooklyn terminals will occupy two solid blocks.

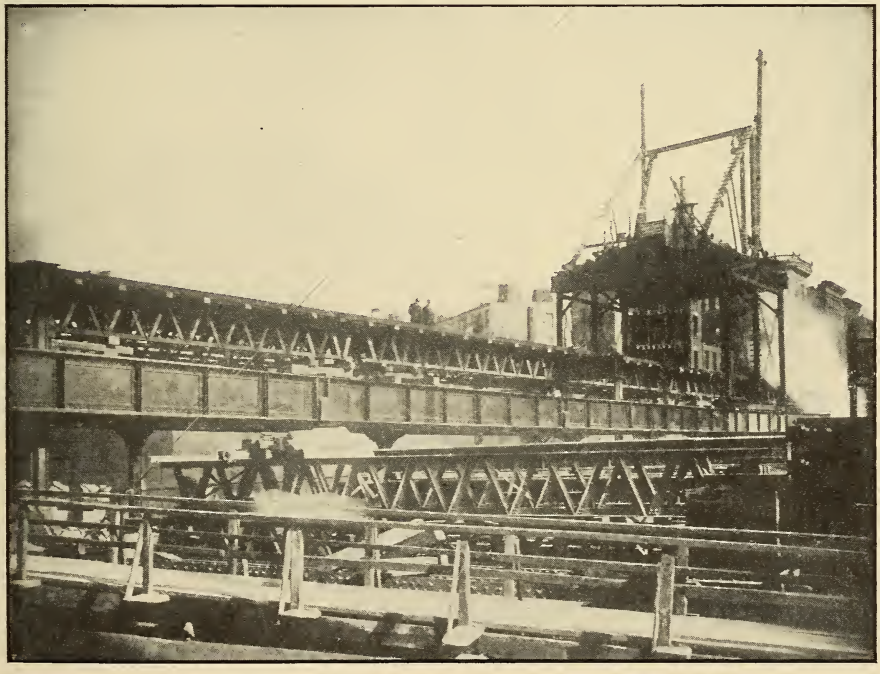
The property acquired for building the bridge, besides that mentioned above, is a strip of land 160 feet wide running along the line of the bridge on each side of the river. The cost of the property condemned in Man-

hattan has been about $8,000,000, while that in Brooklyn cost about half as much. The section demolished in Manhattan was in the midst of the most congested district on the East Side. The buildings, though mostly tenement-houses, were substantial ones and netted the landlords a nice income. The section in Brooklyn was a poorer class of buildings and property, hence the much less valuation.

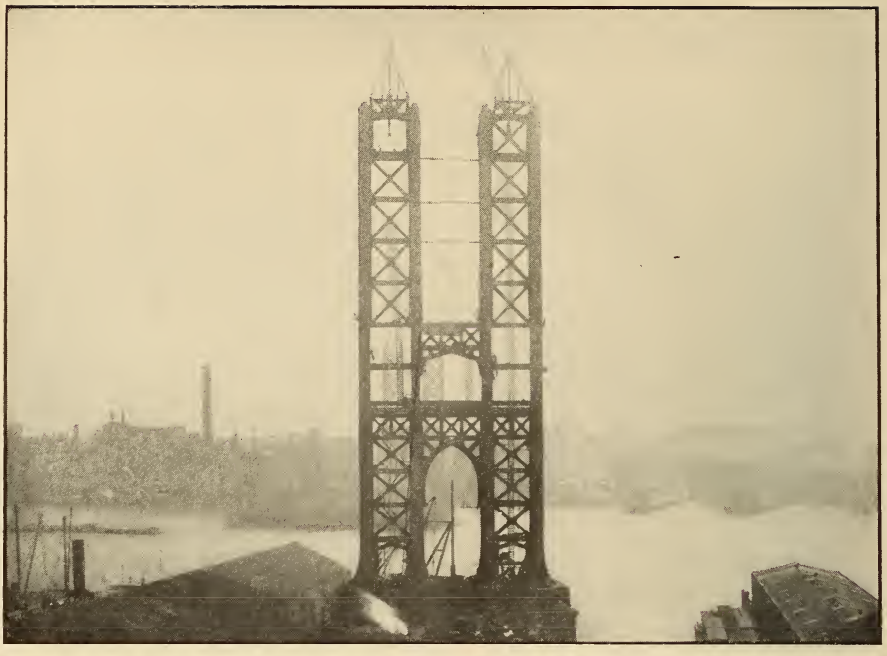
The Flatbush avenue extension, a street 120 feet wide, running from Fulton street and Flatbush avenue to the bridge, was bought with the expectation of building an elevated structure along it; but popular sentiment has changed during the past ten years with respect to elevated railways. Then they were looked upon as a ready means of relieving traffic congestion; now they are considered as a noise nuisance and an enemy to light and air. Then nine-tenths of the people wanted many additional miles of elevated railroads built; now just as large a percentage want no more elevated structures, and many fully believe that within forty years the present elevated railways will be torn down. Mr. O. F. Nichols said: "The existing elevated railways at least will always be with us, simply because we shall never be able to do without them."

The main part of the bridge is the suspended structure, which is 2,920 feet long, that of the river span being 1,470 feet and each side span 725 feet. This is all supported on four cables, which hang in vertical planes carrying four stiffening trusses. The cables are supported by two steel towers, and are fastened at their ends to masonry anchorages. The bridge has a clearance of 135 feet above mean high water for a distance of 400 feet at the centre.

This bridge has the greatest river span, with three exceptions, of any bridge in existence. The Firth of Forth Bridge in Scotland has a span of 1,710 feet. This is of the canti-



CHANGING THE GRADE OF THE SECOND AVENUE ELEVATED RAILROAD WITHOUT INTERRUPTING TRAFFIC



ERECTING THE STEEL TOWER AT THE MANHATTAN END OF THE BRIDGE

lever type. The river span of the Brooklyn Bridge is 1,595 feet 6 inches, while that of the Williamsburg Bridge is 1,600 feet. The last two are of the suspension type. The next longest bridge ever built is that of the Queensboro, also in New York City, one span of which is 1,182 feet. None of these bridges nor any bridge is designed to carry the enormous amount of traffic that the Manhattan Bridge will.

The essential features of any suspension bridge are: First, the cables to support the bridge; second, the towers to support the cables, and third, the anchorages to fasten the ends of the cables. In a large suspension bridge like this the stiffening trusses to distribute the load to the cables are of no small concern. Other features, as wind bracing, the design for taking care of local strains and stresses, size and number of rivets, etc., are mere details that accompany any engineering feat, but which demand careful study and consideration.

One property of all steel structures that the public thinks little about is that of expansion and contraction, and no other property has caused more annoyance to engineers. The technical expression found in all treatises, that steel or iron expands or contracts 0.0000065 of a foot per foot per 1 degree F., seems at first very small and negligible; but when one considers that our climate is so variable that it is common every year to see the mercury register 0 degree F. and 100 degrees F., one begins to realize that even small things count. This means one-quarter of an inch in a 30-foot rail. In walking along a railroad track the most casual observer will notice the joints open in the winter and practically closed during the summer.

In a structure 2,920 feet long a change of 100 degrees F. means a change in length of 1 foot 10¾ inches. This is taken care of in the stiffening trusses by a rocker post on each side of each tower. The post is 12 feet long, with a pin through each end,

one end of which is fastened rigidly to the tower and the other end to the bottom of the truss. The movement may be described as being similar to that of the upper arm and body when the elbow is resting firmly and the body sways, the upper arm acting as does the rocker post. One plate sliding back and forth over another one at different points takes care of the expansion in the roadway and sidewalks. In the tracks the rails are split and slide past one another.

The tower pier foundations are carried to a depth of 92 feet below mean high water. The foundation in Brooklyn rests on bedrock and in Manhattan on coarse sand and fine gravel of a very firm character, as the negligible amount of settlement which has occurred indicates. These foundations were sunk by the caisson method, and are of concrete and limestone masonry, with granite facing above mean low water. Under an extreme condition of loading—namely, with a congested load covering the entire length and width of the bridge — the pressure on the foundation of the piers will be 8.4 tons per square foot. These foundations were completed in 1904, and the same year contracts were let for the building of the anchorages.

The foundation of the Brooklyn anchorage was so satisfactory that only a few piles were driven. The Manhattan anchorage rests on sand and closely-driven piles. The anchorages, as the name implies, are to anchor the ends of the cables. The cables are divided into strands, and each strand is fastened by means of a strand shoe to a pair of eye-bars. The eye-bars are 9 inches by 1 7/16 inches carbon steel, in four lengths, making each eye-bar chain 110 feet

CONSTRUCTING THE ARCH IN BROOKLYN ANCHORAGE

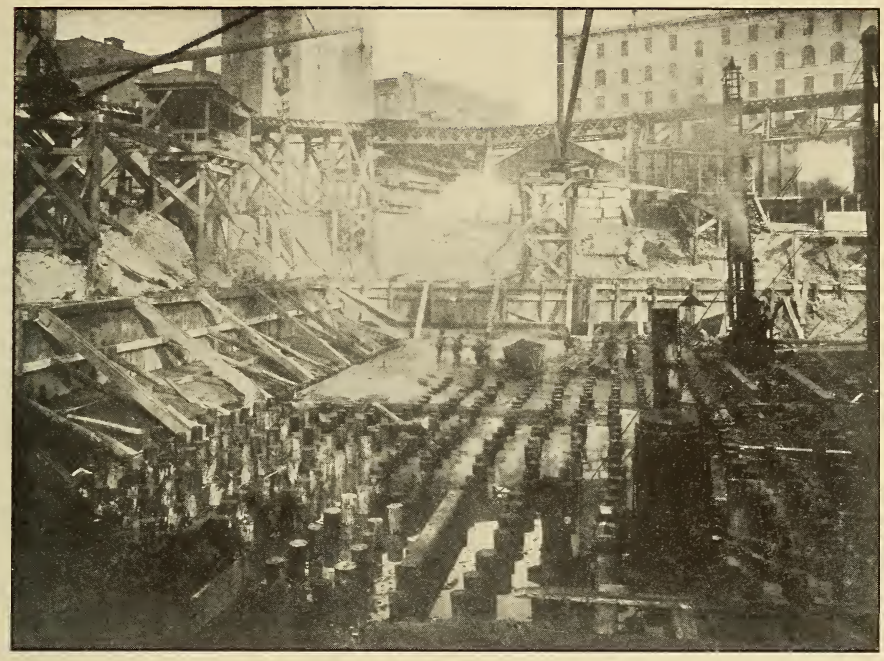
The short bars are to bond the arch with the upper part of the anchorage.

VERTICAL TRAVELERS ERECTING THE STEEL TOWERS

long, all imbedded in concrete, except where the strands of the cables are fastened. These eye-bars are further anchored at their lower end to large steel plate girders, which are also imbedded in concrete at the rear and bottom of the anchorages. There is also steel embedded in the front of the anchorages as an anchor to the wind bracing and to give a rigid connection to the stiffening trusses. This steel, together with that anchoring the cables, weighs 2,700 tons. Besides this, there are 900 tons of steel reinforcing bars used in the construction of the anchorages themselves.

A street runs through each anchorage, necessitating an arch 46 feet wide and 45 feet high. There are 464,000 tons of masonry in the anchorages, which is more than enough to hold the cables, the extra amount of masonry being required on account of constructing the arches.

The towers to support the cables are of steel. Each tower is made up of four vertical posts or legs rigidly connected to the tower foundation pier and to each other. The bottom of each leg is 33 feet long by 5 feet wide, diminishing in size to 10 feet long by 5 feet wide at the top. This gives the towers a tapering effect and an artistic shape. Each leg was divided into thirteen lengths and each length into three parts or sections, the heaviest ones weighing 61 tons. Each section is made up of vertical and horizontal plates or diaphragms, so that every exposed surface is accessible inside, as well as outside. The sections were placed in position by a vertical traveler, a very ingenious device of the contractors. This would place one length of two adjacent legs in position, then pull itself up on this length and place the next section. The traveler, equipped, weighed 65 tons. There are three separate vertical compartments running the entire length of each leg. A ladder is placed in each compartment and a



FOUNDATION FOR THE MANHATTAN ANCHORAGE, SHOWING PILE DRIVER AND PART OF CONTRACTORS' PLANT

The top of the piles is 12 feet below mean high water.

REAR OF MANHATTAN ANCHORAGE, SHOWING GIRDER AND FIRST LENGTH OF EYE-BAR CHAINS

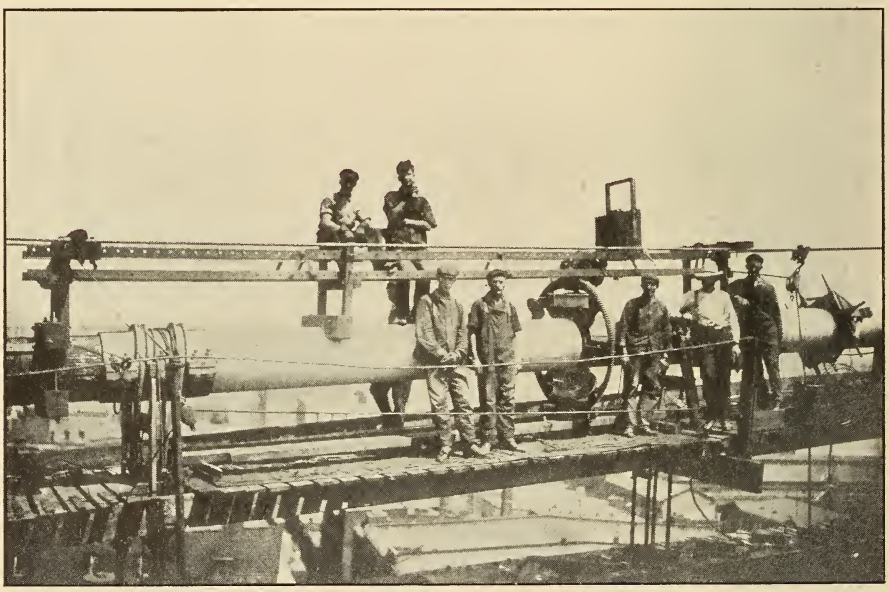
manhole cut through each horizontal diaphragm, so that one can climb easily to the top of the tower through the inside of the leg.

The saddles carrying the cables are fixed to the top of the towers, while the Brooklyn Bridge saddles are set on rollers and move under varying loads and temperature. Under an imaginary loading that would cause maximum deflection, the Manhattan Bridge towers would bend 2 feet 3 inches at the top and still be well within the safety margin. In order to have a record of the deflection of the towers, a bass piano wire is fastened in each outside leg at the top and suspends at the bottom a plumb bob weighing 20 pounds. The extent that this weight moves gives the movement of the tower at the top. At one time during the erection of the stiffening trusses this movement was as much as 8 inches, but at no time since the completion of the bridge has the movement been more than 3 inches.

The weight of the towers is 12,514 tons. The top of the cables is 322 feet and the top of the ornamental work is 336 feet above high water. Features of these seemingly slender steel towers are the speed and economy of their construction compared with the slow and costly construction of the massive masonry towers of the Brooklyn Bridge.

There is no part of a suspension bridge of more importance than its cables. To the engineer, these are simpler to design and to erect than some other parts of the structure. Each of the four cables contains 9,472 wires, laid parallel and closely wrapped to form a cylinder of 21¼ inches diameter, being 5½ inches larger than the cable of the Brooklyn Bridge. Each wire is slightly less than ¼ inch in diameter and is 3,224 feet long. The total length of wire in the four cables is 23,132 miles, which is nearly enough to reach the entire distance around the world.

Before the wires of the four cables are strung a footwalk must be built as a working platform. This is constructed of wood, resting on four small cables. Each cable is made up of four wire cables 1¾



MACHINE FOR WRAPPING THE CABLES

At the left is a cable band with the suspenders passing over it.

BUILDING THE FOOTWALKS ON THE SMALL TEMPORARY CABLES PREVIOUS TO STRINGING THE MAIN CABLE WIRES

The Brooklyn Bridge is seen in the background.

inches in diameter. This makes sixteen separate 1¾-inch cables to be carried across and suspended over the river. On one reel is a cable long enough to reach from anchorage to anchorage, passing over both towers. This reel is placed on the Manhattan tower foundation pier and one end of the cable pulled up to the top of the tower and back to the anchorage, where the end is permanently fastened. The reel, with three others similarly fastened, is next placed on a scow, and the scow is towed across the river. The reels unwind, allowing the cables to lay on the bottom of the river, which, during this process, is closed for navigation by the police patrol and United States harbour boats. The length of time that the river was closed was not over ten minutes. When the scow and reels arrive at the Brooklyn tower the cable is taken off from one reel and the end pulled up over the tower and back to the anchorage. The cable is given such a pull as will cause it to hang about 5 feet below the position of the main cable and is then fastened to the Brooklyn anchorage. The three other cables go through the same process and then four more are brought across, and so on until the sixteen are in place. The engineers, with surveying instruments, give the location for the cables. The wooden walks or four working platforms are then built on these cables and the plant for stringing the wires of the main cables put into operation.

The equipment for work on each cable is as follows: An endless ¾-inch hauling wire rope which is supported on sheaves held in nine equidistant small towers, passes around an 8-foot horizontal wheel in each anchorage. The wheel at the Brooklyn anchorage is driven by a 40 horse-power motor. To the rope is fastened two 4-foot vertical steel sheaves, which hold a bight or loop of the cable wire. These two vertical sheaves—called spiders, because they spin—travel back and forth over the river, spinning out four wires as they go, which unwind from reels situated on the anchorages.

ANCHORAGE DURING CABLE CONSTRUCTION

This shows the endless wire hauling rope, 4-foot vertical sheaves or spiders, the reels from which the spiders take the wires and the strands in the cable where they pass around the strand shoes and are fastened to the eye bars.

The wire is made at the mill in lengths of 3,000 feet and spliced together there with right and left-hand sleeve nuts in lengths of 80,000 feet. One length is wound upon a reel. These reels are delivered at the site and mounted on an axle. The spiders take the wire direct from these reels. As soon as one is emptied another is put in its place, and a field splice similar to the mill splice is made and the process of spinning continues. The wire at the anchorage is passed over a strand shoe shaped like a horseshoe and is carried back over the bridge. There are 256 wires in each strand, amounting to really one continuous wire passed 256 times back and forth over the river from anchorage to anchorage. As each strand is completed, the strand shoe is fastened to a pair of anchorage eye-bars by a steel pin 7 inches in diameter.

In order to obtain the right pull, or tension, as it is called, on each wire, a guide wire, whose length at different temperatures is known, is placed in the same position as the strand that is to be spun. Now it naturally follows that if another wire is placed alongside of this guide wire it, too, would be the right length and have the same tension. This is the process used throughout the cable, and, though it may seem simple, it assures that each wire is doing just as much work as any other wire. It took the spider about eight minutes to run from anchorage to anchorage. The largest number of wires laid in one cable in eight hours was 218. The largest number of wires laid in the four cables in eight hours was 812. The first wire was strung on August 10, 1908, and the last one, in the presence of Mayor McClellan, on December

TWO TUGS TOWING SCOW, WITH FOOT-WALK CABLE REELS ACROSS THE EAST RIVER

The reels unwind, allowing the cables to lay on the bottom of the river. A police launch can be seen up the river holding up traffic. At the extreme right is one-half of the Brooklyn tower.

TRAVELERS AT THE BROOKLYN TOWER STARTING OUT TO ERECT THE SUSPENDED STRUCTURE

The Manhattan tower and anchorage are at the left.

10, 1908. The stringing of 38,000 wires in four months shows the efficiency of methods used and excellent supervision.

The cables, as they leave the eyebars, pass over saddles on the anchorages. These saddles are placed on rollers, to prevent stress in the masonry. The saddles at the towers are each 11 feet long by 6 feet wide and 3½ feet high, weighing 25 tons. This is cast in one piece and bolted to the towers, as before mentioned.

About every 18 feet along the cable a band is clamped to it. Each band consists of two semi-cylindrical concave castings; the upper part has flanges to hold the suspenders, of which there are two pairs at each cable band. The suspenders are 1¾-inch twisted wire rope, with ends socketed with babbit. Each socket is connected to the bottom of the stiffening truss by a nut and bearing plate. There are 1,264 suspenders which carry the load on and the weight of the bridge to the cables. Tests, made by the Bridge Department at the manufacturers, show that it takes a load of 145 tons to break one of these suspender wires. This is an ultimate strength of 215,000 pounds per square inch, the same as the specifications require for the cable wire. Tests for the cable wire show an ultimate strength of 225,000 pounds (112½ tons) per square inch. This means that the strength of each cable is over 30,000 tons. Under a congested load placed in an improbable position the stress on the cable would be less than one-third of the above value. Thus it would be impossible to ever get a load on the bridge large enough to unduly stress the cable. A load that would produce the greatest cable stress would not produce maximum deflection of the towers. There are so many conditions that enter into the calculations of a suspension bridge that they cannot be discussed here.

The cable is wrapped by a serving wire between each band. This wire is slightly smaller than that used in the cables, and is wound around the cables under a stress of 10,000 pounds per square inch by a machine spe-

TRAVELERS 400 FEET FROM THE MANHATTAN TOWER ERECTING THE BOTTOM MEMBERS OF THE TRUSSES, AND BOTTOM FLOOR SYSTEM

The sockets or the ends of the suspenders can be seen where the steel has not been erected. Over the steel work are men painting the suspenders.

cially designed for this bridge, a most ingenious invention by the cable contractor's engineer. We hear sometimes the following criticism: "It will rust out if it won't wear out." This does not apply at all to the cables of the Manhattan Bridge. Each individual wire is galvanized and oil-coated. The interstices or spaces between the wires are filled with a heavy grease. Then the wrapping wire excludes all moisture, and outside of the trusses are made of nickel steel, even to the rivets used in these members. Nickel steel is a little more expensive, but much stronger than carbon steel. The other members and floor systems are carbon steel. The erection of the trusses was carried on by travelers working simultaneously from each tower. These travelers erected first the bottom members of the trusses and bottom floor system. The travelers on each side of the

TRESTLE CARRYING TROLLEYS ALONG SANDS STREET, BROOKLYN, WHILE THE STREET WAS BEING LOWERED 10 FEET

At the left is a masonry approach pier in course of construction.

this, again, is plenty of paint. The weight of the wire in the cables is 6,000 tons. The weight, including bands, suspenders and saddles, is 7,771 tons.

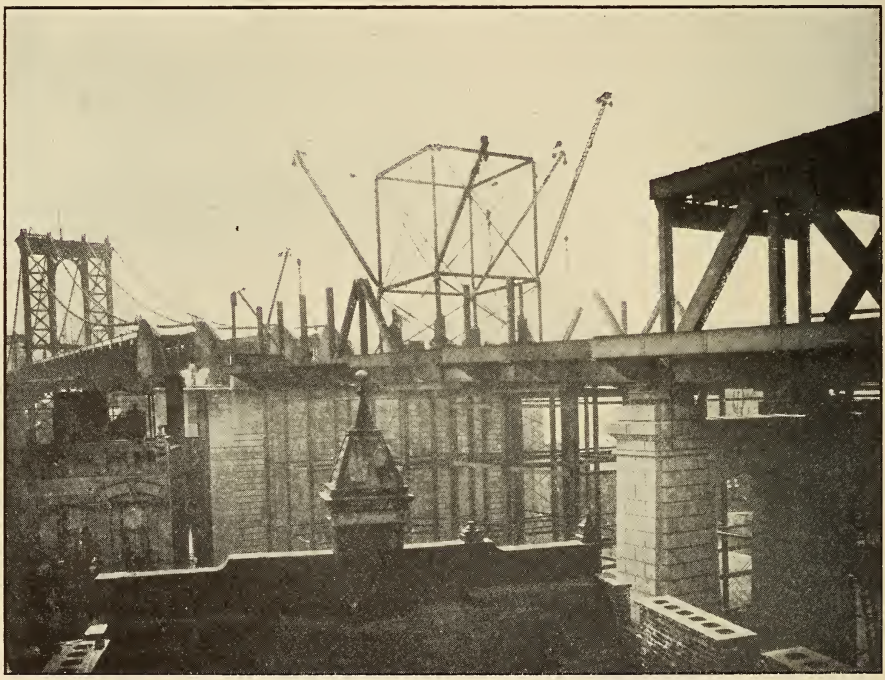
The stiffening trusses, one under each of the four cables, carry and distribute the loads on the floor system to the cables. These trusses are made heavy, so that the stress caused by the load at one point will be distributed over a considerable length of the cables. The main members of towers were then pulled back, after they had reached the centre of the river and anchorages, respectively, and proceeded again on their journeys, erecting the auxiliary members. On the next return trip back to the towers the upper floor system was put in place. No falsework was required, as fastening could be made at once to the suspenders from the cables.

The approaches, reaching from anchorage to street grade, are steel

THE COMPLETION OF THE STIFFENING TRUSSES

The derricks and travelers can be seen near each tower. At the left is the Manhattan anchorage. At the centre is seen the cables where the foot-walks have been removed.

viaducts supported on six masonry piers. The viaducts are similar in Brooklyn and Manhattan. The arrangement for carrying the traffic is the same as described for the suspended structure. The steel was erected on wooden falsework by a large traveler, as shown in the illus-



ERECTION OF STEEL VIADUCT APPROACH

tration. The special interesting feature in the contract for the construction of these viaducts was the lowering of Sands street, in Brooklyn, 10 feet without interrupting trolley traffic and the lowering of Division street, in Manhattan, 6 feet. This latter work necessitated a reconstruction of the Second Avenue Elevated Railroad, which was done without interruption of the elevated service in either direction.

On the terminals an earth fill has been made, on which is built a temporary roadway and sidewalks leading to the approaches. No cars are crossing the bridge at present. The only thing that prevents this is the terminals. Plans for these cannot be settled until traffic arrangements are completed. The Brooklyn Fourth Avenue Subway is the only railway line that is definitely known will cross the bridge. This will take but two of the eight tracks. It is sincerely hoped by all Brooklyn that arrangements will be made in the near future for immediate use of the other six tracks by subway, trolley or elevated railways.

The sidewalks on the bridge are made of a 2-inch reinforced concrete slab, with a ¾-inch wearing surface of mastic asphalt. This surface is the same as that usually seen in park walks, only of a different texture. The roadway is paved with wood blocks laid on planks, which are bolted to the steel. Other finishing features to the bridge are too numerous to give in detail. It might, however, be mentioned that even a single item, as the railings, is a large one. There are 11 miles of different kinds of steel railings, weighing 1,100 tons. There are over 20 miles of electric wire for lighting the bridge. The total amount of steel in the bridge is 60,800 tons, while that in the Brooklyn Bridge is 22,200 tons. The weight of the bridge per linear foot is 25.000 pounds (12½ tons), and will carry an additional load of 16,000 pounds (8 tons) per linear foot. All of the details are of a very heavy and substantial character, while the general appearance of the bridge is light and graceful. One thing noticeably different from other suspension bridges is that the cables are entirely above the suspended structure. There was no engineering reason for doing this, only an architectural one.

At one time as many as 600 men were employed on the bridge. On an average over 300 men were at work continuously from January 1, 1908, to December 31, 1909. Most of the construction work was done during this time. At the first date the steel towers were only partly erected. At the latter date Mayor McClellan officially opened the roadway for the vehicular traffic. Facts and figures could be given until the reader was tired. One cannot realize the vastness of this work unless he has been familiar with similar undertakings. Suffice it to say that it would take one man, working continuously, 198 years to construct just the cables, provided that he could work to as good an advantage as several could. This is over five natural working lives.

The cost of the construction of the bridge up to the present time has been a little less than $13,000,000. The terminals will cost $2,000,000 more. To this must be added the cost of the property, which was about $12,000,000, thus making a total cost in money of $27,000,000. About twenty lives have been lost in the building of the structure. It seems pitiful that men must be sacrificed in such an undertaking, but what more beautiful monument could be erected to their memory? What would more benefit their fellow men than this monument, partly erected by themselves and for which they gave their lives?

COAL SUPPLY FOR THE RAILWAYS OF INDIA

By Ivan Rosedale

RAILWAY men and those engaged in colliery work in India are naturally interested in the question of sources of fuel supply for the railways of the country. An examination of the Administration Report made public by the Railway Board furnishes interesting information upon this subject, and the development of new collieries is shown to have been largely affected by the increase in railway traffic and the extension of the different lines.

During the year 1908 the total production of coal from the collieries of India and Burma amounted to 12,770,000 tons. Of this amount 3,600,000 tons was consumed by the railways, this being an increase of 261,000 tons over the previous year; besides which there were consumed 79,630 tons of foreign imported coal.

Railways were first started in India during the year 1853, when twenty miles of road were opened. During the past twenty years there were added during the rule of the Marquis of Lansdowne 3,928 miles; under the Earl of Elgin, 3,536 miles; under Lord Curzon, 6,255 miles, and under the first three years of the Earl of Minto 2,281 miles. Every mile of new line constructed meant the penetration of coal into a fresh district and an increased demand for coal. The advent of the railway stimulates trade, while the reduction of fuel expenses encourages the construction of mills and factories. Wood is still the staple fuel in up-country districts distant from the railways, but the cost of wood is increasing every year, owing to the felling of the forests, so that industrial prosperity is entirely dependent upon the possibility of procuring cheap coal.

Although the price of coal at the pit mouth in India is cheap compared with the cost in England, yet the enormous distance over which it has to be transported before it can be used in the furnaces of locomotives renders it an expensive item in railway operation. The East Indian Railway receives its coal at a price of 5.05 rupees per ton, freight included, and this is the cheapest of any of the large lines. The Great Indian Peninsular pays 10.58 rupees per ton; the Bombay-Baroda Railway pays 14.04 rupees per ton; and the South India Railway, 15.66 rupees per ton. Many of the lesser lines pay even higher figures than these.

There is one State colliery at Ballapur, which, in 1908, produced 45,299 tons, with a resulting profit of 86,047 rupees. This colliery is situated in the Central Provinces, and supplies coal to mills as well as to the railways. Another colliery in the Central Provinces, worked by the Great Indian Peninsular Railway, is that of Mophani, which produced 45,351 tons during the year, but at a loss of 98,761 rupees, or £6,000. The Giridih collieries of the East Indian Railway produced 671,744 tons of coal during the year. The coal is not sold to the public, but is all taken by the railway, which obtains its fuel at an extremely low figure. The average number of persons employed daily was 5,934 in 1908.

There are two collieries worked by the Northwestern State Railway, Dandot and Khost. During 1908 Dandot raised 28,787 tons of coal at a loss of £2,300, employing 902 persons. At Khost colliery 715 people were employed and 31,055 tons of coal raised at a loss of £2,200. The number of deaths was twenty-five, caused chiefly by an explosion underground. There is a factory for the manufacture of compressed fuel at Khost, which employed twenty-five operatives, and produced 15,350 tons in 1908, at a profit of £660. The Northwestern Railway has another small factory, making compressed fuel, at Haranpur, employing eleven persons and producing 5,268 tons, but at a loss of £540.

DUSTLESS ROADS AND BITUMINOUS BINDERS

By Wm. F. Prouty, Ph.D.

The following article is an extended abstract of a paper prepared by the chief assistant to Dr. Eugene Allen Smith, State Geologist of Alabama. Although primarily prepared in view of the conditions obtaining in the Southern States of America, it contains so much valuable information of general value in the improvement of highways in other parts of the world that it is given here from the Bulletin No. 11, upon Roads and Road Materials of Alabama, issued as a publication of the Geological Survey of that State.—The Editor.

THE present tendencies in road construction are far different from what they were ten years ago, and there has probably been no time in the history of road building in the United States when the tendencies have been changing more rapidly than they are at the present time. The factors instrumental in causing this change of tendency in road construction and maintenance are many. Chief among them, however, should be mentioned the following: 1. Bond issues and money taxation make it possible to construct roads of greater initial cost and better class, and also to construct them more cheaply than it would have been possible with the older form of labour taxation. 2. The people are beginning to realize the great financial, social and educational losses occasioned through bad roads. 3. The rapid development of automobile transportation has made absolutely essential hard, smooth roads for their efficient use. The automobile men are more often the men of influence. 4. The rapid wear and the great amount of dust on certain classes of these hard, smooth roads is preventible by certain methods of treatment. 5. The public is awakening to the great nuisance and damage caused by dusty roads.

The most advanced step in the treatment or construction of roads is that which, besides making the road the most serviceable for the condition of traffic to which it is to be subjected, makes it also a relatively dustless road. It is this tendency to the construction of dustless roads to which attention may be called.

There are a number of questions which naturally suggest themselves at this point, such as: Where should dustless roads be built, how should dustless roads be built, and why should dustless roads be built?

We cannot hope to answer these questions with any degree of detail or exactness, but it may be worth while to give the subject a general kind of study.

The subject of dustless roads is not a new one. The dust nuisance has been recognized by cities for many years, and the city streets have been built with the thought in mind of having them yield as little dust as possible. Most cities also have watered or otherwise treated their streets for many years to lay the dust where traffic has been heaviest; but not until within the last decade has much advance been made in the treatment of roads, other than city thoroughfares, for the laying of dust. The automobile has been the chief agent whereby the advance along this line has been made. The amount of dust raised by teams is meagre in comparison with the amount raised by the swiftly moving automobile. Discomfort, danger to health and damage to property along the dusty roads have each been a factor in influencing the public to rid themselves of this costly nuisance.

The public cannot hope to make any large percentage of the roads of a dustless nature, nor is that at present necessary; but the roads of the suburbs and the great public thoroughfares, which are daily receiving a large amount of traffic, especially by the automobile, must be treated to lessen the dust evil, if we are to work at all for our own and the public welfare.

Each community must settle for itself what roads should be treated to make them less dusty. The extent of the work is limited in the reverse ratio of wealth and enterprise of the people. This phase of the subject is not open, then, to discussion, except to urge that the people fully awaken to the harmful effect to health and property of the dust and to bend every effort to eradicate the nuisance as far as possible.

There is no absolutely dustless road that will remain so for any great length of time, for if fine material does not come from the road itself it will, to some extent, come from extraneous localities. The term dustless must then be used in a relative sense and not in the absolute.

How dustless roads can be obtained is the question that most concerns the practical man. There are two possible methods:

1. By laying the dust that forms.
2. By preventing the formation of dust.

In the first method, water or oil is added by some process to the dusty surface, and the dust particles are held by the surface tension or the cohesion of the liquid. The efficiency of this treatment varies largely with the viscosity of the liquid used and its liability to absorption or evaporation.

Water can be but temporary, as it is highly volatile. The hygroscopic salts, those which have the power of gathering moisture from the atmosphere, as well as the lighter oils, are each also more or less temporary as dust-layers.

In the second method the material used is such that its wear is very slight, or else it is composed of a substance which does not pulverize, and, consequently, does not yield dust. Here we deal either with the higher priced material for paving, such as brick, block, cement, etc., or else the heavier bituminous mixtures.

For the benefit of those who are contemplating either the palliation of dust on the roads or the construction of dustless roads, I shall attempt briefly to discuss some of the methods and materials used for this purpose.

The materials naturally group themselves, as already suggested, into those which are of a temporary nature and into those of a more lasting character. In the first class belong such materials as are effective for one season, or only a part of one season. Such materials are easily volatile in their nature, and, if one of the oils, has a low viscosity.

WATER

For many years water was the only one of this class of dust layers which was used to any considerable extent, but with the introduction of oils the percentage of streets treated with water has considerably decreased. It is apparent that in some cases the true economic value of water as a dust layer has been lost sight of in the development of other dust palliatives. If the same study were given to the economical use of water that is now being given to oiling the cost of using it would be considerably lowered. Some of the more enterprising cities are now watering the streets from tank cars on their electric lines, thus greatly reducing the cost of application along those streets.

It is very difficult to get cost data concerning the use of water as a dust layer because of the lack of records; but an average of several records which are at hand, taken in different places in the country, shows an average cost of from two and one-half to four cents per square yard per season.

HYGROSCOPIC SALTS

Hygroscopic salts, which are produced in large quantities by some of the chemical establishments, have been used to no small extent in various localities, especially where freight on the salt is not too excessive. The results, as a rule, have been successful. One of the hygroscopic salts which, perhaps, is used more widely thna any other is calcium chloride.

This class of dust layers can be placed on the road either in solution from a sprinkling cart or else in a dry form by hand or machine. The amount used, in case of calcium chloride, is one and one-half pounds per square yard per treatment. The action of the salt is to gather moisture from the atmosphere, and one treatment is sufficient to supply moisture to the road sufficient for laying the dust for a period of from two to three months, depending, of course, on weather conditions. The cost per ton of the calcium chloride is about $13, F. O. B. at the manufacturers. The cost of spreading the material is small. In Washington, D. C., the cost per square yard per season for laying the dust by this salt was four cents in 1910. In Albany, N. Y., for the same year, it is estimated to have cost less than water.

There are practically no injurious results from the use of this salt, and where it can be as cheaply employed as water its use is preferable, because of the less frequent interval of its application and the consequent less obstruction to traffic.

EMULSIONS

The application of oily substances as dust layers through the medium of emulsion has been tried with varying success. Many experiments have shown emulsion to be highly economical and effective. Petroleum, tars, etc., are also miscible with water through the action of a saponifying agent or soap.

Many kinds of emulsions are now manufactured. Their application is by means of the sprinkling cart.

*Cost data for emulsified road oils are here presented from a number of cities for the summer season of 1910:

Montclair, N. J., cost per square yard per season, less than water.

New London, Conn., cost per square yard per season, 25 per cent. more than water.

Waltham, Mass., cost per square yard per season, 2¼ cents; water costs 3 cents.

Buffalo, N. Y., cost per square yard per season, 1.78 cents on macadam.

Boston, Mass., cost per square yard per season, 1.7 cents, eight applications.

Springfield, Mass., cost per square yard per season, 2 cents for seven and one-half months.

"In binding the dust on the street pavements, experiments have been made in various parts of Berlin with a particular preparation, and, according to official report, a sprinkling with a 1 to 100 solution of this preparation and water, by means of ordinary street sprinklers, successfully kept the dust bound, even in the streets with the largest traffic, for four to five weeks. The cost per square meter (1.196 yards) for six oil solution sprinklings a year was less than one-seventh of the average annual cost for water sprinkling."

It will thus be seen that, as a rule, the general cost for treatment by emulsified oils is less than by sprinkling with water. There is also an accumulative beneficial effect provided the oil used is an asphaltic oil, so that the cost for the second year should be somewhat less than for the first.

HEAVIER BITUMINOUS MATERIALS

Of the heavier bituminous materials which have been used in the United States in the past few years for bituminous road construction we have the following classes: fluxed native asphalts, oil asphalts, residual asphalts and semi-asphaltic oils, light

* Data from Good Roads Magazine, March and May, 1911.

oils, coke-oven tars, coal-gas tars and combinations of coal-gas tars and water-gas tars, combinations of asphaltic materials and tars.

From the investigation of the last few years it is evident that refined coal tar is much to be preferred to the crude coal tar as a binder; it is also shown that crude water-gas tar is valuable only as a temporary binder, and that its most satisfactory use is as a dust layer. Light applications of it should be sprinkled on the road whenever the dust becomes excessive.

The present tendencies as to the kind of bituminous binders used and the methods of applying them are briefly summarized by Mr. A. H. Blanchard in a paper read before the American Association for the Advancement of Science, 1910:

"*Surface Treatment.*—In the surface treatment of macadam and gravel roads several lines of development have been especially noticed: first, a more general use of refined coal-gas and water-gas tars in place of crude tars; second, an extraordinary increase in the various kinds of asphaltic oils, combined with sand, gravel or stone chips, to form a carpet wearing surface; third, an increase in the use of light oils for the purpose of allaying dust on State roads, and thus, to a certain extent, preserving the surface of the road by the retention of the top dressing; fourth, a substitution of mechanical distributors of both the pressure and gravity flow type in place of hand application methods.

"The practice of the past three years has amply demonstrated that the success of superficial tarring is dependent upon the recognition and adoption of those fundamental principles which were laid down by the French engineers in 1903. As those principles have not been adopted in many instances in the United States. they will be given here in brief First, superficial tarring should be done only during dry and warm weather, in order to obtain efficient and economical results; second, the road must have a dry, smooth and durable surface; third, all dust must be thoroughly brushed off in order to facilitate the adherence of the tar; fourth, after the distribution of the coat of tar it is necessary, in order to avoid a slippery surface, to apply a dressing of sand, gravel or stone chips. The practice of some prominent English engineers does not include the adoption of the fourth recommendation cited, as it is maintained that a top dressing is not an essential element of a non-slippery tarred surface.

"A well-developed plan of annually treating certain roads of a system with a thin coat of bituminous material is being adopted by certain States. This practice embodies the recognition of the fundamental principles of economy and efficiency in modern highway construction—namely, the adaptation of method and material to local conditions.

"*Penetration Method.*—In connection with the use of bituminous materials by penetration methods certain noteworthy tendencies are apparent. Most important are the employment of distributing apparatus and the formation of broken stone courses in such a manner as to endeavor to secure the maximum uniformity of distribution of material and the definite limitation of penetraiton.

"The unfortunate delay in the application of the penetration method, due to damp stone, has been overcome in some instances by the employment of mechanical surface heaters.

"A modification of the penetration method is known as the 'puddling method.' The top course in this case is filled with screenings puddled by watering and thoroughly rolled. After the surface dries out it is picked up. The bituminous material is then applied, a coat of chips is spread and the surface rolled. After the surplus chips are brushed off, a flush coat of bituminous material is ap-

plied. The application of another coat of chips and a final rolling completes the process.

"Another modification of the regular penetration method has been employed during 1910. In this method the foundation is thoroughly filled and rolled. A layer of sand is spread upon the foundation course to a depth of about an inch. Refined tar, heated to about 250 degrees Fahr., is then applied to the coat of sand. The top course, composed of broken stone varying from three-fourths to 2¾ inches, is spread and rolled, the lower voids being filled with the bituminous mastic. After consolidation a second coat of refined tar is applied. As soon as possible after spreading the second coat of tar a layer of stone chips is spread and rolled. A third coat of refined tar is then applied and the surface finished by rolling a covering of screenings or sand.

"*Reconstructed Old Roads.*—In the reconstruction of old roads there has been a general employment of the method of picking up the old surface to a depth of 2 inches to 4 inches by the use of mechanical scarifiers, placing a thin coat of new metal on the loosened surface, and then constructing a bituminous pavement by the penetration method.

"In both the construction and reconstruction of roads by penetration methods the surface is finished in various ways. One method is to spread a coat of chips or sand after the first coat of bituminous material is applied, roll thoroughly, and after the road has set up sufficiently, open it to traffic. Another method is to apply a second coat of bituminous material before the application of a layer of chips. The bituminous material for the flush coat may or may not be the same as used for the first coat. A layer of chips or sand is then spread over the flush coat and thoroughly rolled. A third method is essentially the same as the second cited, except that a layer of chips is applied to the first coat of bituminous material, thoroughly rolled and the surplus chips brushed off before the application of the flush coat of bituminous material.

"*Character of Material Used.*—From the standpoint of the character of bituminous material used it is of special interest to note the increased use, particularly in 1909 and 1910, of fluxed natural asphalts and oil asphalts especially manufactured for application to unheated crusher run stone.

"*Mixing Method.*—In the construction of bituminous pavements by the mixing method a number of improvements and developments should be noted. Some attention has been paid to having the stone dry and reasonably clean. Although advantages accruing by using clean and dry stone are recognized, the practice has been far from satisfactory, only very crude methods having been thus far employed. The practice of heating stone on plates has been used to a certain extent with deleterious results. In a few cases mixing machines and tar coating machines have been employed in connection with the construction of bituminous pavements which are to cost not over $0.90 to $1 per square yard. The types of mixers which have been used to date are more or less unsatisfactory, especially when bituminous materials are used which are solid at ordinary temperatures or which flow with considerable difficulty when cold. During the season of 1911 considerable development should take place in the heating of stone by mechanical dryers, and also in the use of new types of mixers especially manufactured for the purpose of mixing bituminous materials with a mineral aggregate.

"In various parts of the United States sand, gravel and earth have been mixed in place by various processes with bituminous materials in the endeavor to form an impervious, dustless and durable road surface. This work is being watched with considerable interest, as the

utilization of local materials for the aggregate in many instances reduces the cost of construction materially. The limitation in the weight of traffic to be carried throughout the year under all climatic conditions is one of the most important points under discussion at the present time in connection with the above methods.

"A new type of construction recently introduced by Logan Waller Page, director of the United States Office of Public Roads, is known as oil cement concrete. In this process fluid residual petroleum is added to the usual ingredients composing concrete.

"From the standpoint of the nature of the materials used, again it is noted that there is an increase in the use of refined tar, considerable employment of heavy asphaltic compounds, and also the employment of combinations of tar and asphalt, the most notable increase, however, being in the use of heavy asphaltic oils, which can be mixed readily with broken stone as it comes from the crusher.

"There has been a marked tendency on the part of highway engineers during the past three years to appreciate more fully the importance of the various chemical and physical properties of bituminous materials. Many engineers and manufacturers now wisely advocate using different grades of the same type of bituminous materials for varying local conditions and for different methods of bituminous construction. During 1909 and 1910 bituminous materials for use in the construction and maintenance of roads have been purchased in two ways—namely, by buying direct from the manufacturer a product known under a trade name and by purchasing the material under specifications. The old custom of simply purchasing bituminous material under a trade name without investigation of its properties is being replaced by the second method. The object of the second method has been to cover one or more of the following points: First, to secure uniformity in the material furnished for a given contract; second, to obtain a compound which conforms to certain requirements with reference to the chemical and physical properties of the material which are considered essential; third, to provide a standard by which it is hoped that a satisfactory material may be duplicated on other contracts. The effect of the various physical and chemical properties of bituminous materials on their value as road binders is being investigated by a special committee of the American Society of Civil Engineers. Standard methods of testing bituminous materials is the subject of investigation by a sub-committee of the American Society for Testing Materials."

It may be said in general that the cost of using a bituminous binder on a macadam road is, in the case of the penetration method, about 25 cents and in the case of the mixing method about 35 cents over and above the cost of ordinary macadam construction.

One of the most successful moves made in the past few years for the laying of dust and the maintenance of the road surface is that brought about through the use of bituminous binders with the local materials, such as sand, gravel and earth. Roads made of such mixtures have given splendid service, and the continuance of this custom means the growth of many of our suburban districts. The cost for thus treating a road is much less than the cost for the construction of a bituminous macadam, and under the light traffic the results would be in many ways equally as satisfactory. In Massachusetts, where a large amount of road has been built of this nature, a good grade asphaltic oil is used with a sandy gravel. Two layers of one-half gallon per square yard each are used, and sand to a thickness of one inch is rolled into each layer. The cost per mile for a width of 15 feet varies from $1,800 to about $2,000.

It is very difficult to say which of the processes of using the bituminous binder, by the mixing or by the penetration methods, is the better. Both of the processes have their ardent adherents. In this question, as in all similar questions, circumstances must be taken into account. It seems to be the general opinion of engineers at the present time, however, that uniformly better results are obtained by the mixing process than by the penetration process, provided the stone and binder are properly handled, but that the mixing method is too expensive unless machinery of suitable character can be employed in the mixing. When the binder is applied to the road in the penetration method better results seem to be had when this application is made from machine with liquid under considerable pressure. In the construction of the roads in Massachusetts, where the penetration method is employed very largely with good results, a pressure of from 75 to 100 pounds per square inch on the liquid is employed.

OIL CEMENT

The experiments with oil-cement concrete, which were tried by the Office of Public Roads in a few experiments in 1909, were more extensively carried on during 1910. It is yet too early to predict the economical use of this mixture; but the results, as far as they have been observed, are very favourable.

A fluid oil, either a fluid residual petroleum or a cut-back petroleum residue, has been employed. Such oils have been added to a cement mortar to an amount equal to from 10 to 20 per cent. of the weight of the cement used. In the experiments in Washington, D. C., the cement thus prepared was applied to a foundation which was constructed in two courses of from one-half to one and one-half inches broken stone placed to a depth of five inches loose upon the prepared sub-grade, and which after rolling had received screenings from one-half inch in diameter to dust, and had been finished as in ordinary macadam road work. The thickness of the oil cement concrete used was equal to about an inch and a half to two inches, which was either placed upon the foundation and then covered with about two and one-half inches of broken stone and rolled until the voids in the broken stone were entirely filled with the oil-cement concrete, or else the broken stone was first added and mixed with the oil-concrete and then applied to the road and tamped until the voids were filled. In the seven experiments conducted varying amounts of oil-cement stone and sand were used, so as to discover, if possisible, the best percentage of each. The cost data of these experiments show a range of from $1.15 to $1.25 per square yard for the total cost.

ROCK ASPHALT

Another important material that has come into use quite extensively in the last few years is native rock asphalt. This material is a sandstone which has received a deposit of bituminous material through the percolation of bituminous bearing oils or gases through it in former times. The bituminous matter is found coating the grains of the sandstone and in some cases in quantity sufficient to nearly fill the voids in the stone. In general, the percentage of the bituminous material does not run over 7-8 per cent. of the mass of the rock. The Kentucky rock asphalt has been considerably used for the purpose of constructing dustless roads. A test road made by the United States Office of Public Roads in 1907 in Bowling Green, Ky., was inspected in December, 1910, and found to be in good condition, "the cross section was well maintained, and the surface rang sharply under the blows of horses' hoofs." The stone was thoroughly bonded, and showed no sign of raveling. "A small specimen of the rock asphalts, when dug up and warmed in the

hand, showed that the bitumen still had considerable life." See circulars 89, 90, 92 and 94 of Office of Public Roads for the particulars of this experiment.

In regard to the purchase of bituminous materials, it may be said that the cost alone may have but small influence upon the suitability of the material for the particular work in hand.

It should always be the rule to have the materials tested and to buy such materials only as will satisfy the tests essential for that particular class of work.

THE NEW BUSINESS CENTRE OF THE UNITED STATES

By A. E. Stilger

YEARS ago, in quaint Knickerbocker days, the Bowery was the centre of New York's activities. Gradually the march of progress pushed farther uptown into what at that time was the mere farming outskirts of the city. Lower Broadway, Fourteenth street and Twenty-third street became successively with the passing years the ever-increasing active vortex in that great whirlpool of commerce, the unequaled metropolis of America.

But at the present day these, too, have become, in a measure, a portion of the past, and the incoming and outgoing throngs, the busy, whirling tide of life and action now centres anew in the throbbing heart of the greatest city of America in Thirty-fourth street.

It was only about eight years ago that ground was first broken for the erection of the now famous terminal of the Pennsylvania Railroad, which now stands out as a monumental specimen of the builder's art. At that time Thirty-fourth street presented the appearance of a rather quiet and prosperous residential section, with business places interspersed here and there. Gradually a wonderful transformation has taken place. Many of the old brown stone mansions and old business buildings have been demolished to make room for the new and modern office and loft buildings, demanded by the many and varied business enterprises which have been continually moving into the district. Even the few remaining residences have been reconstructed for business purposes. Every class of business is well represented; here the new buildings for the principal houses of merchandise have been erected, among which may be mentioned the establishments of Messrs. James McCreery & Co., Tiffany & Co., James McCutcheon & Co., John Forsythe, Revillon Frères, Oppenheim, Collins & Co., Rogers, Peet & Co., R. H. Macy & Co., Saks & Co., Bonwit, Teller & Co. and Gimbel Brothers.

Underneath is heard the roar and rush of the rapid expresses, bringing vast throngs from New Jersey and Pennsylvania, while the suburbs furnish their quota by means of the subway and elevated roads, all tending towards this favored locality, in which not one, but many, of the best advantages in trade await the shopper and business man alike.

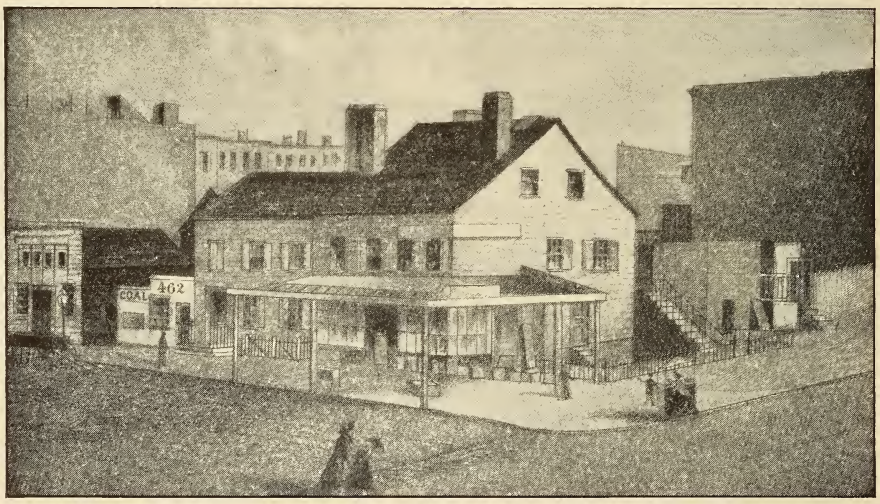
In close proximity to the great station of the Pennsylvania Railroad stands the handsome new general post office, rapidly nearing completion, and destined to be the centre of postal activities and the centre around which commercialism will revolve.

An excellent indication of the commercial importance of this centre appears in the extent to which the newer and larger hotels are seeking the locality. The Waldorf-Astoria and the Herald Square Hotels have been well established for several years, while the new Vanderbilt Hotel and the Greeley Square Hotel are rapidly nearing completion. Other well-known and successful hotels in the vicinity are the Imperial, the New Grand, the Martinique and others—all up-to-date in their equipment and service, and all bringing business men into close touch with this centre of commercial activity.

A FIFTH AVENUE CORNER IN 1849

Thirty-fourth street is thus becoming the Mecca of the commercial pilgrim from all parts of the United States, and here every facility is afforded for the transaction of business. Numerous banks are here located—the Chelsea Exchange Bank, just off the corner of Thirty-fourth street and Eighth avenue; the West Side Bank, directly opposite on the northwest corner, and a branch of the Corn Exchange Bank in the Pennsylvania Railroad building. East of Broadway may be mentioned the Knickerbocker Trust Company, the Sherman National Bank, the New Netherland Bank, the Mutual Bank and the North River Savings Bank, all having ample capital and surplus to take care of the requirements of the trade, convenient and accessible from all points.

These facts are well known to those who have had the opportunity



A MURRAY HILL BUSINESS ESTABLISHMENT IN 1865

of traversing this busy street, but it is not so well known that Thirty-fourth street is in the midst of the largest manufacturing centre in the world. The section embraced between Twenty-third street and Forty-second street, on the west side of New York, taken on a comparative area basis, however, does include a greater proportion of manufacturing establishments than any other area of similar size anywhere.

Unlike other manufacturing districts, the section of which Thirty-fourth street is the backbone contains establishments devoted to nearly every conceivable line of business, both in the actual operations of manufacturing and in the commercial operations with which they are closely connected.

In the departments of manufacturing associated with iron and steel there may be mentioned the works of the John T. Williams Company, makers of iron and bronze grilles, screens and railings; the Prince Iron Works; the Merrill Spring Co.; Benj. Fox's Sons Boiler Works; the J. B. & J. M. Cornell Iron Works; Benj. Lowenstein, proprietor of the Nassau Smelting & Refining Works, and others. Among manufacturers of clothing are included the National Cloak & Suit Company; Messrs. M. Bloch & Co.; May Manton Pattern Company; S. Floerscheimer Bros., and Vogel & Co., not to mention the work of the great department stores of Macy & Co., Saks & Co., James McCreery & Co., Altman & Co., and others, to whom reference has already been made. The building trades are represented by the George A. Fuller Company and by the veteran builder, Hugh Getty, while among the brewing establishments may be named the Hoster-Columbus Brewing Company, the Evans-Hudson Ale Company and the Anheuser-Busch Company. The wide general character of the manufacturing of the district is shown by the inclusion of Messrs. Runkel Bros., manufacturers of chocolate; the Knickerbocker Candy Company, the Lyons Toothpowder Company, the Schaetler Office Furniture Company, the Leins Piano Company, and Messrs. Bramhall, Deane & Co., makers of ranges. Other firms in the neighbourhood include the Berlin & Jones Envelope Company, the

THIRTY-FIFTH STREET AND THE HUDSON RIVER FIFTY YEARS AGO

This spot is now the centre of the produce trade, with railroad and shipping terminals.

Photograph by H. N. Tiemann.

FIFTH AVENUE AND THIRTY-FOURTH STREET IN 1893

On the site of the old Astor residence in the foreground now stands the Waldorf-Astoria Hotel. The old Stewart residence, across Thirty-fourth street, has been replaced by the Knickerbocker Trust Company.

Metropolitan China Company, the Dreyer Carriage Repository, Joseph Stern & Son, Ludwig Bauman & Co., the German Grob Company Marble Works, the T. B. Haviland Music Company, and Messrs. Robert Teller Sons & Dorner.

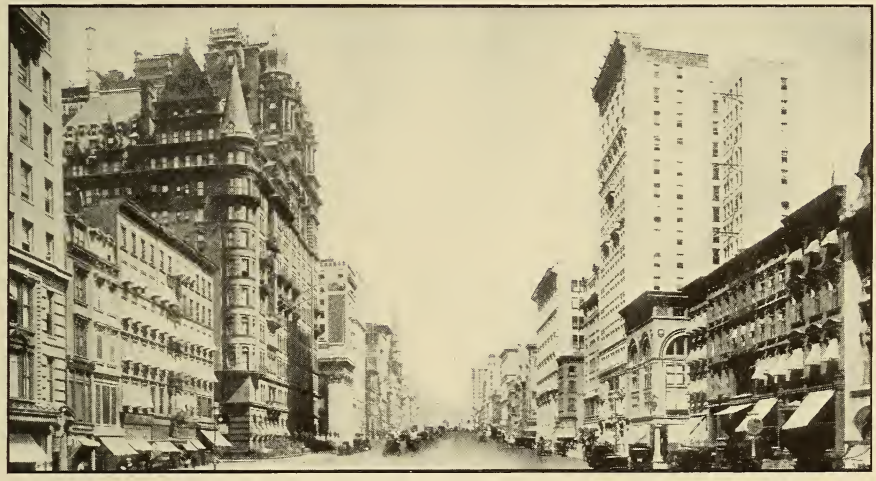
This is the section in which is found the Hay Exchange, the largest receiving and distributing station of its kind in the world; here is also located the Manhattan Market, in which general produce from all parts of the country is dealt in on a most extensive scale; while the establishments of Swift & Co., Cudahy Packing Company, Armour & Co., Sulzberger & Sons Company and the New York Butchers' Dressed Meat Company cover allied lines. Mention may be made as well of the Haeger Storage Warehouse, the Ingersoll Grain Elevator Company, the Dunbar Box & Lumber Company, the Wright Lumber Company and many others, of whom mention will be made hereafter.

In full accordance with the increasing importance of the district the widening of Thirty-fourth street should be accepted as a timely increase of the traffic capacity of such a rapidly growing thoroughfare. The removal of unsightly structures and the clearing of the sidewalks has enabled the increased space to be added to the main highway without reducing the capacity of the sidewalks, besides improving, to a marked degree, the appearance of the street, rendering it truly worthy of the position which it is to hold in the business future of New York, as well as of the country.

The illustrations which are given cannot fail to make an impression of the rapid transformation of the district more emphatic and abiding than any written statement.

Thus, no longer ago than 1893 the

corners of Fifth avenue and Thirty-fourth street, on the west side, were occupied, respectively, by the staid old brick mansion of the Astor family and the more recent marble residence of Mr. A. T. Stewart, while the avenue above and below this point was almost wholly filled with the stately residences of wealthy New Yorkers; and any idea that the neighbourhood would be soon given over to business would have been scouted as absurd. The illustration



Photograph by J. P. Hall.

FIFTH AVENUE AT THIRTY-FOURTH STREET IN 1910

The Waldorf-Astoria stands on the site of the old Astor Mansion, and the changes of seventeen years over the opposite illustration are shown.

indicates clearly the quiet and reposeful aspect of the vicinity at that period. The photograph of the same district taken in 1910 shows the magnificent Waldorf-Astoria Hotel occupying the site of the old Astor mansion and covering the remainder of the block as well, while the Stewart mansion has disappeared to make way for the beautiful building of the Knickerbocker Trust Company, and the avenue above and below is lined with great business buildings.

Herald square, at the intersection of Broadway, Sixth avenue and Thirty-fourth street, is shown in the photograph as decked out for the Dewey celebration in 1899, and the surrounding low and old-fashioned buildings indicate clearly the moderate degree to which general business had invaded the district. If anything were necessary to show that the march of improvement had scarcely begun here at that time, the primitive horse car appears, wending its way across the street, and having no competition with automobiles or motor trucks. The modern contrast is seen in the bird's-eye view of the whole area, this remarkable photograph having been taken from the tall tower of the Metropolitan Life Insurance building, at Twenty-third street and Madison avenue, looking toward the northwest, and showing the utter transformation of the district which had taken place in the course of little more than a decade.

There is no better indication of the development of a district than the successive increases in the value of real estate, and in this respect the Thirty-fourth street line in New York shows the most marvelous growth of any portion of the land. The old Broadway Tabernacle, which stood

Photograph by H. N. Tiemann.

HERALD SQUARE IN 1899, SHOWING THE LOW BUILDINGS, HORSE CARS AND GENERAL CRUDITY OF THE NEIGHBORHOOD

On the opposite page is shown the development of the same place after a lapse of twelve years.

quietly for so many years at Broadway and Thirty-fourth street, cost $50,000 when the gray stone church was built, was sold a few years ago for nearly a million dollars, and has since changed hands more than once at increasing prices, until the present Marbridge building occupied the site.

The American Society of Mechanical Engineers purchased its house in Thirty-first street near Fifth avenue in 1890 for $60,000, and disposed of it a few years since at an advance of 100 per cent.

Most remarkable of all has been the increase in value of the corner plot at the northwestern intersection of Broadway and Thirty-fourth street, a piece of ground covering less than 1,200 square feet, or about one-half an ordinary city lot. About ten years ago this piece of land was sold for $375,000, and changed hands a few years later for $500,000, and it has now been again sold, this time the price being $1,000,000, or nearly $870 a square foot. What this means may be realized by recalling the fact that the next highest price for land in New York was that paid for the lot at the southeastern corner of Broadway and Wall street, the centre of the old financial district, which brought $600 per square foot. Thus the Thirty-fourth street plot, which a few years ago had nearly reached the highest price for Wall street property, has now passed far beyond it in the open market.

The extent to which the public press has realized the location of the true centre of New York appears in the fact that nearly all of the great newspapers are moving into the district, beginning with the New York *Herald* and continuing with the New York *Times,* the *Sun,* the *American* and others, while those which have not already planned to move have established branch offices in the vicinity.

(To be continued.)

Photograph by J. P. Hall.

THE NEW BUSINESS CENTRE OF AMERICA

Panorama looking northwest from the Metropolitan Life Insurance tower at Fourth avenue and Twenty-third street. *The Times* building is seen in the distance, and the partially completed station of the Pennsylvania Railroad is to the left of the centre. The illustration covers the area between Twenty-eighth street and Forty-second street, from Fourth avenue to the North River.

INFUSION STEEL PROCESSES

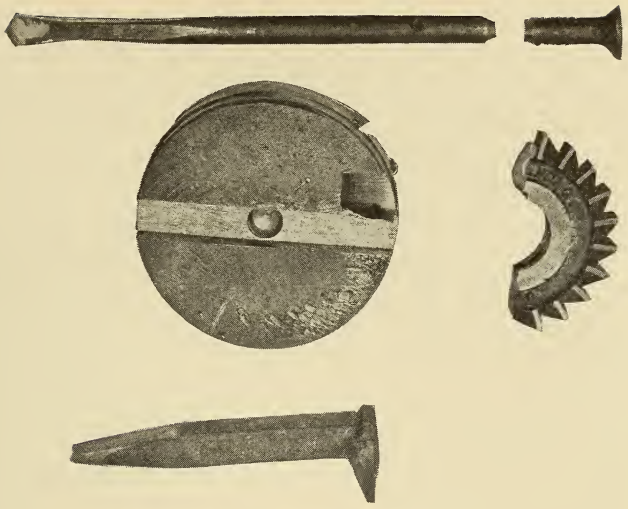
By A. J. Thompson

ONE of the oldest methods of making steel from iron was that known as the "blister" or cementation process, the iron being heated in a receptacle in contact with some suitable form of carbon until a portion of the carbon became absorbed into the metal, the blistered appearance of the surface giving the name to the process. The material thus obtained was rendered homogeneous by melting in crucibles, and subsequently used for the manufacture of cutlery and similar products. The possibility of thus dissolving carbon in iron by contact at high temperatures, away from the action of oxygen, naturally led to the operation long known as case-hardening, in which formed articles are heated in contact with a carbonizing material, and subsequently quenched in water or oil, the result being the formation of a thin skin of steel upon the surface, and thus enabling the product to resist wear or attrition.

With the development of the so-called alloy steels it has been found that there are other substances besides carbon which give most desirable properties to steel, and hence there has arisen a number of processes for making different kinds of steels by the addition of certain ferro alloys to the melted carbon steel, these alloys containing the desired ingredients, such as Tungsten, manganese, nickel, vanadium, titanium, etc., in known proportions, and enabling the desired percentage of the especial element under consideration to be added in a simple and practicable manner for regular commercial manufacture.

In order to extend this process of adding various materials to iron or steel without fusion, various experiments have been undertaken, and some interesting laboratory results have been obtained. The principal advantage of such methods lies in the possibilities which they offer to use material of moderate cost and low grade in the manufacture of implements and machine parts, and then to convert the material for a certain depth into a more resistent quality without change of form or injury. If, for example, it were possible to use ordinary machine steel for the construction of parts subjected to heavy wear, and then by exterior treatment convert the metal for a considerable depth into a high-carbon steel without injuring the general machined form, a marked advantage would follow. In like manner the use of low-carbon steel for gear-wheel construction, cutting the teeth in the soft metal, and subsequently infusing carbon and other elements into the finished surface to sufficient depth to give the high resistance of a special steel of predetermined character, would enable some difficult requirements to be met most effectively.

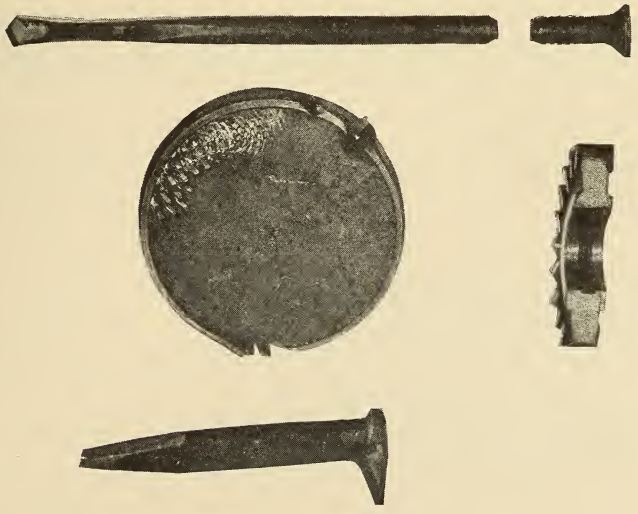
Various methods have been resorted to to obtain similar results, one of the most notable being that of the manufacture of armour plate. The much-desired combination of a hard surface and a softer tough backing has been attempted by rolling hard and soft steel plates together, but operative difficulties



TOOLS INFUSED WITH "STELPRO"

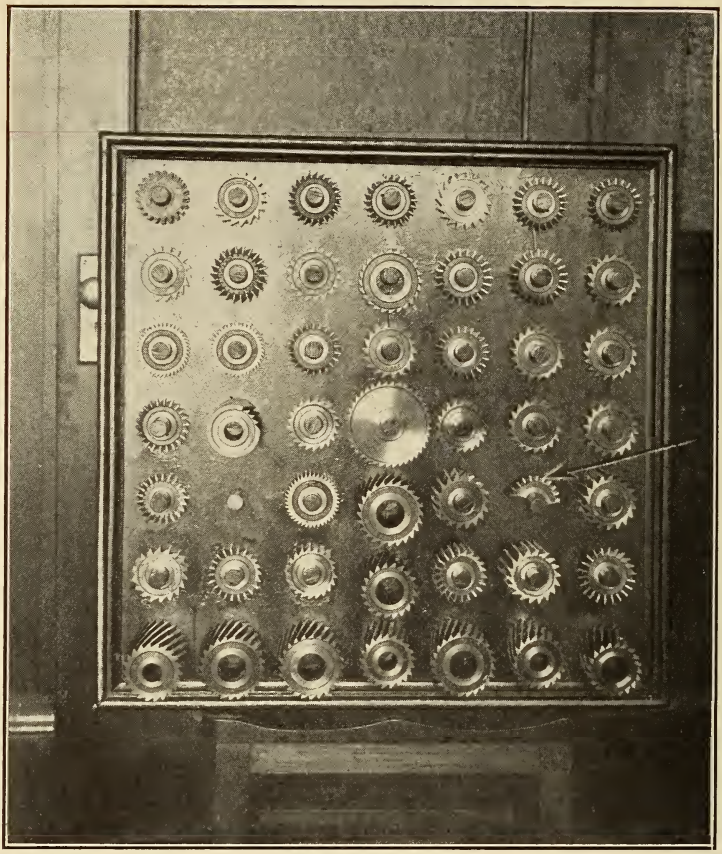
In the middle is shown a piece of unannealed chrome nickel steel cut with the broken cutter, drilled with the drill above, made from an ordinary 60-penny nail and cut with chisel made from an ordinary railroad spike.

naturally appear in such a process. The production of a hard plate, and the subsequent softening of the back portion by heat treatment, forms another process, and this has given good results when the thickness of the plate is sufficient to permit the heat to act upon the back without penetrating through the mass of metal to the hard front portion. For plates of moderate thickness, however, such as are used for gun shields, etc., the rapidity with which the effect



BACK VIEW OF SAME PIECES AS SHOWN ABOVE

The cutter shows the depth of infusion.



MILLING CUTTERS MADE OF OPEN-HEARTH AND BESSEMER STEELS INFUSED WITH "STELPRO"

The arrow indicates the cutter which was used on chrome-steel disc.

of the heat treatment occurs renders the process impracticable.

More recently there has been developed a method which is practically an extension of the older case-hardening operation, a so-called "infusion" process, acting by absorption of the carbon and other elements into the metal from without, after the article has been formed from material of a lower grade.

The principal modification which this infusion process makes over the ordinary case-hardening methods lies in the character of the carbonizing material, and the notable effects appear in the greater depth to which the carbonizing action is effected, and the gradual change from the affected portion to that of the original character.

In general, the infusion process employs as the original material a very soft steel, thus enabling the cost of the original material to be kept at a minimum, and also permitting the machining to be done rapidly and effectively. The waste, being from the low-grade material, represents much less loss than would be the case if the best tool steel were employed, while the infusion process has to be applied only to the formed parts. After machining, the pieces to be treated

SECTION OF BAR OF JESSOP'S UNANNEALED TOOL STEEL

Turned off with tool made of an ordinary 60-penny spike infused with "Stelpro" and held in Armstrong holder.

are packed with the hardening mixture, that composition of this varying according to the effect to be produced, and the box is then subjected to predetermined temperatures for a period of one to four hours, according to circumstances.

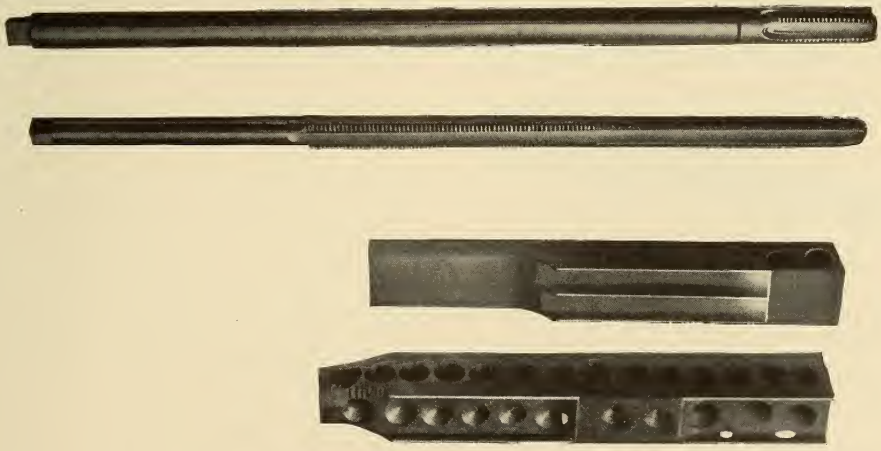
Upon removal from the action of the heat the finished articles are quenched, either in water or in oil, and treated in precisely the same manner as if they had been originally made from tool steel.

It is found that not only carbon, but also the more desirable elements used in the production of modern alloy steels may be introduced into soft steel in this manner, while all the operative manipulations involved in making and machining special steels are eliminated, the infusion being effected after machining. This permits the process to be applied to a great number of purposes, such as small tools, including taps, dies, drills, reamers and milling cutters of all kinds.

It is also available for machine parts, such as gears, cone and roller bearings, spindles, etc., and to numerous parts of agricultural implements, automobile parts and parts of railway machinery.

The ability to harden the exterior of soft steel products makes the process especially applicable to the manufacture of burglar-resisting material in the production of steel safes, vaults, bars, etc.

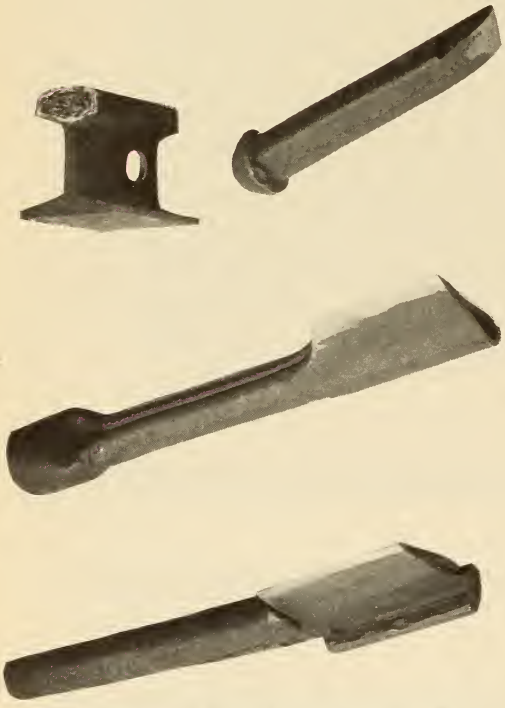
For many purposes the use of high-grade tool steel would be pro-



BELOW ARE SHOWN PIECES OF JESSOP'S UNANNEALED TOOL STEEL DRILLED AND MILLED WITH OPEN-HEARTH TOOLS INFUSED WITH "STELPRO." ABOVE IS A PULLEY TAP AND ALSO A STAY-BOLT TAP, BOTH MADE FROM OPEN-HEARTH STEEL AND INFUSED WITH "STELPRO"

BULLET FIRED FROM RIFLE AT ARMOUR PLATE OF INFUSED STEEL REBOUNDED AND IMBEDDED ITSELF IN GUN STOCK

Distance from plate to muzzle 36 feet; muzzle velocity, 2,700 feet per second. Position of bullet indicated by arrow.



EXAMPLES OF TOOLS MADE FROM ORDINARY MATERIAL AND TREATED BY THE INFUSION PROCESS

Lathe tool made from a bridge rivet picked up on Broadway. Axe made from ordinary gas pipe. Axe made from flange of 12-pound Bessemer rail. Section of same rail showing depth of infusion.

hibitive on account of cost, while the possibility of converting the exterior into material of the desired grade after manufacture removes entirely such difficulties.

We thus have, in the infusion steel process, a method of producing upon articles made of low-cost soft steel such portions of special steel as may be desired at will, and the possibilities of such a method in the development of manufactured products will indicate themselves to the engineer and machinist. The illustrations which are given herewith show what has been effected by the process more clearly than any description can do.

A particularly interesting incident appears in the case of a test which was made of protecting armour plate treated by the process, the hardened surface causing the rifle ball to rebound with such directness that it struck the stock of the gun from which it had been fired, imbedding itself in the wood and narrowly escaping the person of the marksman by whom the shot had been fired.

A MODEL MANUFACTURING ESTABLISHMENT

THE NEW PLANT OF THE BEST MANUFACTURING COMPANY.

IT has been said that most large manufacturing plants are not originally planned so as to secure the maximum efficiency of operation, but that they usually grow from small beginnings, with the development of the business, and the extensions have to be made as best they can, taking into account the available ground and the requirements of transportation, power transmission and general local conditions. It sometimes happens, however, that a concern which has already been developed to large proportions decides to erect a new plant, and being possessed of large experience in the particular requirements of the special line of manufacture concerned, it is able to design and erect shops which are far better adapted to efficient production than any plant of irregular growth could possibly be.

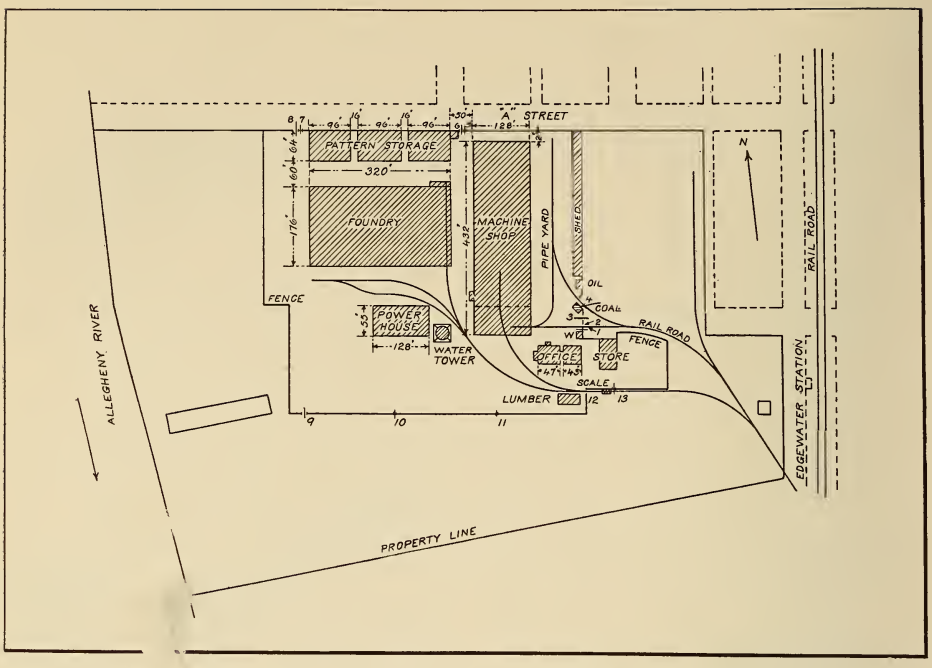
An excellent example of a complete manufacturing plant, designed and erected in the light of previous experience and success, is seen in the new works of the Best Manufacturing Company, situated at Oakmont, about 12 miles above Pittsburg, on the Allegheny River. This plant, intended for the manufacture of valves, pipe-fittings, pipe-bends and special castings, is particularly well located as regards transport facilities, lying between the tracks of the Pennsylvania Railroad and the bank of the river, and is served by a spur track and by its own special station of Edgewater.

The general arrangement of the property is shown in the plan, the heavy lines indicating the portion in use; while a group of houses for workmen has been built in the section north of A street, and a rest house and athletic field provided.

The spur from the railroad enables raw materials to enter and finished products to be shipped, the terminals entering the pipe yard, the foundry stock yard, the machine shop and the foundry. In addition to these external connections there are ample internal arrangements, the raw material, such as coke, pig iron, limestone, etc., being delivered to the charging elevators for the foundry cupolas, while the pattern lumber goes to the storage shed and drying kiln.

While all portions of the plant itself are well above high-water mark, there is a portion of the property outside of the fence which is at a lower level, thus affording ample space for the deposit of foundry refuse for many years to come. Within the works the transport of material is provided for by an industrial railway, together with ample crane equipment, enabling all handling to be effected with a maximum of speed and a minimum of expense.

As seen from the general plan of the plant, the main buildings are the machine shop and the foundry, which are placed at right angles to each other. At the east side of the machine shop is the pipe yard and pipe storage shed, with the office building at the south end. On the north and west sides of the foundry is the yard for the storage of flasks. Also on the north side of the foundry are located three pattern storage buildings. On the



GENERAL ARRANGEMENT OF THE NEW PLANT OF THE BEST MANUFACTURING COMPANY

south side of the foundry is the stock yard for storage of raw material, with the power house beyond. The lumber shed is located southeast of the machine shop, and to the east of the building is located a small storage building for supplies and tools.

It is seen that the arrangement is thus most convenient for the handling of work. Patterns and flasks come to the foundry from the side next the moulding floor, while the stock for the cupolas is located on the side of the foundry nearest them. The cleaning room for castings is in the end of the foundry next the machine shop, and the castings are taken direct to the main bay of the shop, where they are stored until needed for machining, or to the casting storage section in one corner of the shop. Cars are shunted about the plant as may be needed, and are loaded in the machine shop or foundry by overhead traveling cranes. The size of the plant can best be appreciated by reference to the figures on the plan of arrangement. The machine shop is 432 feet in length by 128 feet in width; the foundry 320 feet in length by 176 feet in width, and the power house 128 feet in length by 55 feet in width.

Machine shop, foundry and power house are all of the modern steel frame construction, with brick curtain walls and cement tile roofs on steel trusses. They are provided with exceptionally high windows, giving very effective lighting at all points in the buildings.

FOUNDRY

At the north side of the grounds are three corrugated steel pattern sheds, each having three floors for the storage of patterns. The lower floor is arranged for the heavier patterns and above are racks, three shelves to a rack, all properly lettered and numbered, and with patterns arranged according to size,

and each one card indexed so that its position can be specified on any job ticket. The distance from pattern shed to foundry is comparatively short, 60 feet, and between the foundry and these sheds is the flask storage yard, with industrial track leading from the yard into the foundry and turntables enabling any flask or pattern to be transferred easily and quickly to any part of the foundry. The foundry is arranged in three bays, that on the north side being devoted to the cleaning of castings, the repair and alterations of flasks and the moulding of the smaller patterns. In the center bay is the location of the floor moulds, where heavy patterns, cores and flasks, and for the moving of castings. That in the core room is a 5-ton girder crane, made by the Morgan Engineering Company, while over the pit and loam floor are a 15-ton and a 30-ton girder crane of the same make, and along the side of this floor, next the cupolas, are two 5-ton jib traveling cranes to serve the ladles and handle the lighter local traffic. Over the north bay are a 10-ton Morgan and a 10-ton Whiting crane.

In the floor moulding for large special castings the lower half is moulded in the floor, while a big flask is used for the top half.

Loam molds and sweep up forms

BIRD'S-EYE VIEW OF THE BEST MANUFACTURING COMPANY'S NEW PLANT

large pieces are cast; and in the south bay is found at the west end a space for small valve castings; in the middle the cupolas and at the east end the core room. On the mezzanine floor, back of the cupola, is the chemist's laboratory. On the second floor is the charging platform, and west of this is the brass foundry.

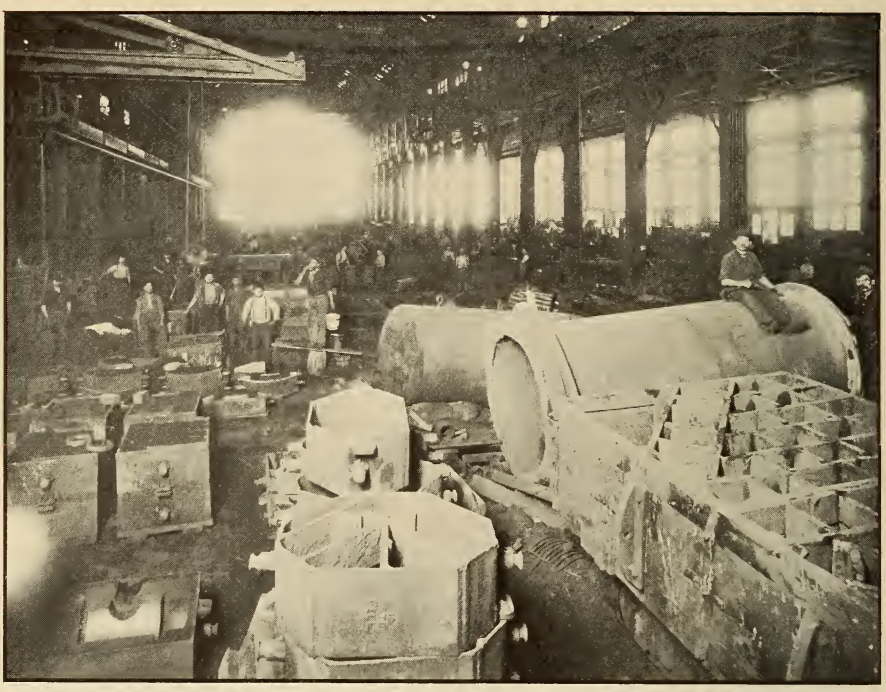
The equipment of the foundry is very complete, moulding machines being used wherever they can be of advantage, metal flasks being provided and specially shaped to the patterns for standard work, and metal core boxes for the smaller work.

At all points cranes are installed for the convenient handling of

are used for large pipe and other castings, this work all being done in the center bay, and being of necessity hand work, since no two pieces are alike.

In the north bay are made the moulds for the smaller castings and standard fittings. Tabor compression machines, roll-over machines and jarring machines are all in use with standard patterns, flasks and facing boards, to secure rapidity and accuracy. Flasks are shaped specially to fit the patterns in order to give a firmer mould and also to save in the amount of sand needed.

The flask altering shop at the west end of the north bay is provided with a swing cut-off saw,



GENERAL VIEW OF MOULD FLOOR IN THE FOUNDRY

a rip saw and a drill press, each driven by an individual motor.

At the east end of the north bay castings are cleaned by means of hand work, pneumatic chipping hammers, tumbling barrels and the sand blast.

The two cupolas in the south bay have capacities of 12 and 30 tons per hour, and are charged from a second-story floor served by a hydraulic plunger elevator. On this floor is also located the brass foundry, where castings are made for small valves and the brass parts of the large valves; also the Monel metal castings. Schwartz furnaces are here used, supplied with oil fuel and air blast, and arranged like Bessemer steel converters.

Between the cupolas and the core room are the three large core ovens. These are heated by natural gas, with an arrangement for coke-firing, if necessary; and are served by the 5-ton crane which runs over the core bay, also the trucks from the ovens can be run out far enough to reach under the cranes in the main bay. In the manufacture of the best products the core oven is a very important feature, for it is a prime necessity that the core shall be exactly right and of proper temper. For some of the smaller castings a green sand core is used, but for the complicated shapes and for all of the larger work the core must be carefully baked.

(To be continued.)

There is probably no more interesting development in the application of engineering to industry than the growth of the German merchant marine, and hence we believe that the portrait of Herr Albert Ballin, under whose active management much of this progress has been made, will be of interest to our readers.

Albert Ballin was born at Hamburg, on August 15, 1857, and, after his graduation from the Gymnasium at Hamburg, he entered his father's shipping company, in connection with which he spent considerable time in England, thus acquiring at first hand a thorough knowledge of British methods. In his twenty-ninth year he became general passenger agent of the Carr line, a powerful rival of the Hamburg-American Line, and in 1886 he entered the service of the Hamburg-American Line as manager of the passenger business. Here his ability made itself apparent, and he was soon advanced to membership in the board of directors, and he has been chairman of the board of directors at Hamburg for a number of years.

The result of his able and vigorous management is apparent in the dominating position which the Hamburg-American Line has taken in ocean transport during the period of his incumbency. The fleet has been increased from twenty-six small steamships to more than four hundred vessels, the largest fleet sailing under a single house flag. The capitalization of the company has been raised from fifteen million marks to one hundred and twenty-five million marks, and the tonnage now reaches the figure of one million, two hundred and ten thousand tons. The Hamburg-American Line now includes sixty-eight different services, with more than three hundred ports of call.

Much of this tremendous growth has been due to the energy and ability of the head of the line, and the development, not only of comfort and luxury on regular lines of travel, but also in the inauguration of pleasure cruises, has resulted from his initiative and activity. The recognition of merit in inventions and the appreciation of the fact that the modern steamship is essentially a hotel of the highest class, in addition to its function as a means of safe and certain transport, have had much to do with the development of the Hamburg-American Line, and it is to the wise administration of Herr Ballin along these lines that much of the eminence of Germany on the seas is due.

ALBERT BALLIN,

CHAIRMAN OF BOARD OF DIRECTORS, HAMBURG-AMERICAN LINE

See reverse side.

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ELECTRICAL POWER IN THE TRANSVAAL

By Rowland Gascoyne

UNTIL the last few years the use of electricity as a motive power in the Transvaal was very far behind other parts of the world. For a long time the value of electricity for lighting purposes had, however, been fully known, and so had the convenient transmission of electrical power for pumping purposes on the mines; but outside this limited application it was only during the last two years that its full value has been recognized and adequate steps taken to bring it to the front. Within the next two years, however, electrical power on the Rand will probably be applied to mining purposes to such a large extent that its use will have assumed larger proportions than in any other mining field in the world.

It was not until the year 1905 that the serious application of electricity as a motive power to mining and milling operations on the Rand was considered. In that year a small electric winder was tried underground at the Village Main mine, and it was decided to drive some of the stamps by electricity at what are known now as the East Rand Proprietary Mine. Mechanical engineers did not, however, regard the proposed introduction of electrical power with complacency, but took steps immediately to show that steam plants could work at half the consumption of fuel electrical engineers gave them credit for, and at the Village Deep mine experiments showed the low consumption of 25.5 pounds of steam per shaft per horse-power-hour and a mechanical efficiency of 85 per cent. In that year the British Association for the Advancement of Science visited South Africa, and electrical power for the Rand undoubtedly received an impetus from the papers read at the meetings, not the least attractive side of the question being the possibility of utilizing the Victoria Falls for generating electrical power for the Rand, a visit to the Falls being included in the excursions of the association. The proposals of the African Concessions Syndicate to install a generating plant at the Victoria Falls and to convey the energy 750 miles to the Rand gave rise to considerable discussion, both in the Transvaal and Europe, and not a little opposition came from the Dutch section of the Transvaal population to the proposals, although the feasibility of the scheme had not by any means been established. The proposals of the African Concessions Syndicate, although they failed to materialize, had the effect of drawing attention

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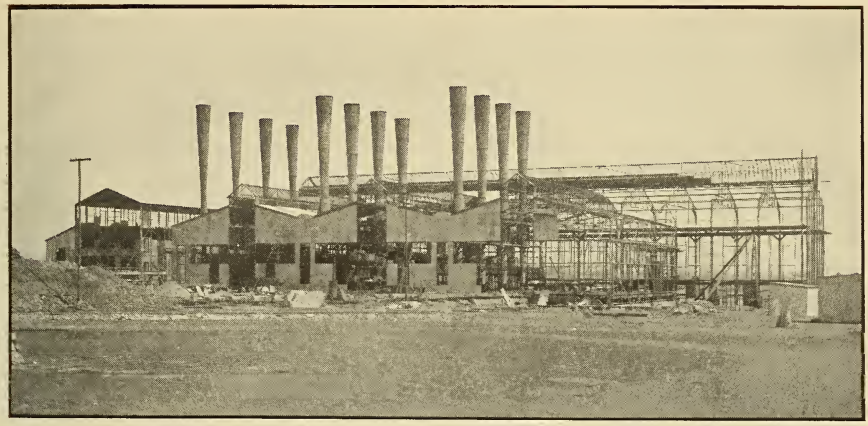
to the many attractions of the Witwatersrand as a field for electrical power, with the result that a company was ultimately formed to acquire the existing small power stations and to erect generating plants fitted for the requirements of the Rand, and on such lines as would conciliate the opposition of the Boers. The promoters even went so far as to pay for options over farms belonging to Boers possessing political influence ostensibly for sites for proposed works, with the result that a great deal of this opposition was removed. The company ultimately formed took the name of the Victoria Falls & Transvaal Power Company, and, instead of adopting the Victoria Falls scheme, established their generating stations in the Transvaal and to use Transvaal coal, a proposal which, it is needless to say, disarmed a good deal of the local opposition to the proposals.

The Transvaal possesses extensive coal resources; but coal mining has never been a highly remunerative business, and the colliery companies were up in arms at once in opposition to the proposal to abolish steam power on the Rand, seeing that millions of capital had been sunk in connection with the collieries. The gold mining companies, however, were, of course, prepared to favour any scheme likely to materially benefit the gold mines; and as several possessed important interests in some of the largest collieries, the opposition was only half-hearted, and after going through the process of a government enquiry an Act, No. 15, 1900, for the regulation of power companies was passed. Permission on these lines was obtained by the Victoria Falls Power Company with the name of the Transvaal Power Company added, and the company thus came into existence with the primary object of supplying the Rand gold mines with electrical energy. The company, however, did not come upon the scene before several gold mining groups had decided to erect stations on their own account, such as, for instance, at the East Rand Proprietary Mines, and Kleinfontein on the Eastern and at Randfontein on the Western Rand.

The Victoria Falls & Transvaal Power Company is, however, by far the most important undertaking, its present capacity being not less than 175,000 horse-power, to which will soon be added an additional large generating station; and it is to this scheme attention must be, therefore, first given. The proposed position of the generating stations of this concern naturally gave rise to some discussion. The collieries would have preferred that the stations be established in the centre of the most important coal field and power transmitted to the Rand. This would have saved railway rates on the coal consumed at the stations, a not unimportant consideration when it is remembered that the railage cost at present is over 7/- per ton. Water was scarce, however, on the coal fields, and it would have involved a transmission line some hundred miles in length to the centre of the Rand. The site of two of the stations has been, however, fixed on the Rand near Germiston, where water is plentiful, and at Vereeniging, close to the Vaal River, where coal—but of low-grade quality—is likewise comparatively abundant. The old station at Brakpan, acquired from another concern, has also been improved and retained.

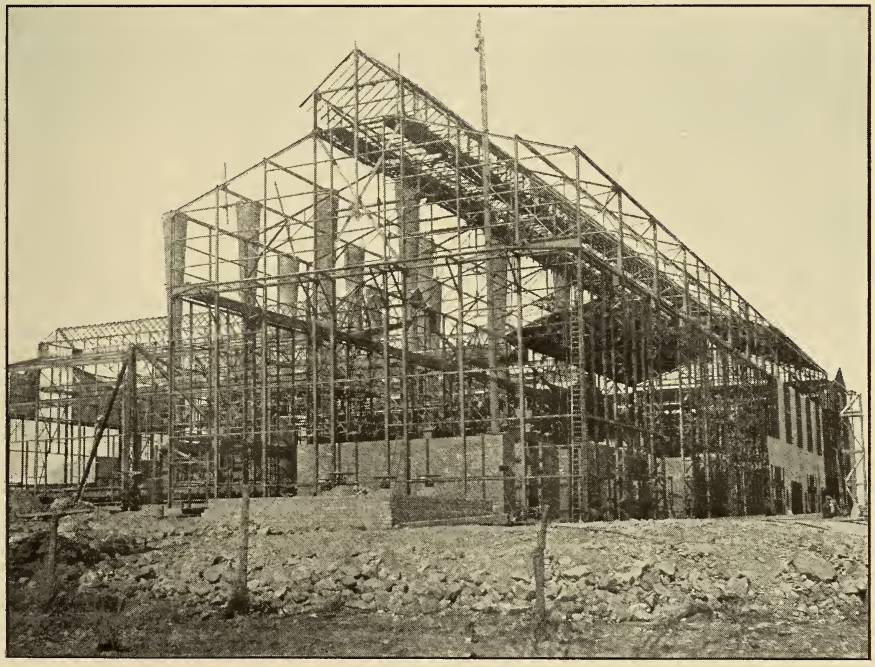
ROSHERVILLE STATION

The Rosherville station is situated between Germiston and Johannesburg, close to the dam of the same name, and is the most important of the generating stations at present in use by the Victoria Falls & Transvaal Power Company. It not only supplies electrical energy to the gold mines, but likewise compressed air in bulk to the Eckstein group of mines. The generating plant at this station consists of five turbo-generator sets of 12,000 kilowatts each, and



ROSHERVILLE POWER STATION UNDER CONSTRUCTION

are at present the biggest units at work in the Transvaal. The steam turbines are of the impulse type, each of 18,000 horse-power. The boilers, economizers and chimneys are all arranged in suitable units, each with its own installation of induced draught. Chain-grate mechanical stokers are used, and everything is designed with the object of saving labour and fuel costs as much as possible. The switch gear is remote controlled, with the bus-bars sub-divided and sectionalized, being built into fireproof cells. The compressed air plant, previously referred to, consists of four steam turbine-driven turbo-air compressors, from



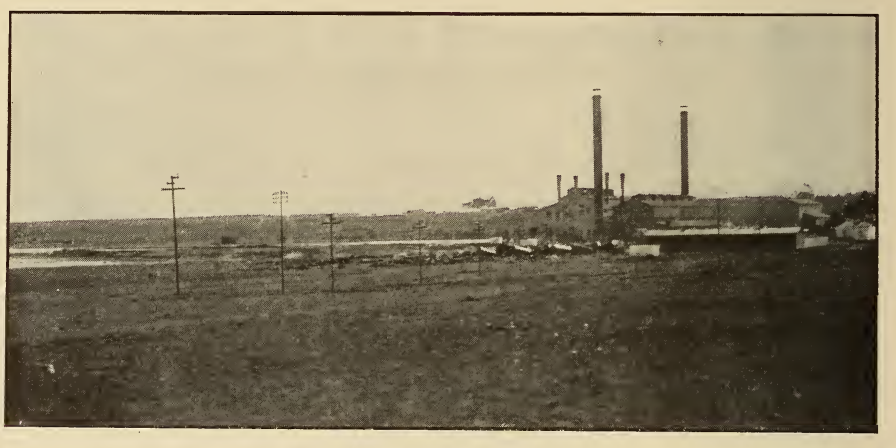
CONSTRUCTION OF ROSHERVILLE POWER STATION

four to five thousand horse-power, being probably the largest air compressors hitherto brought into use. There is likewise a sub-station erected at the Robinson Deep property, due south of the city of Johannesburg and about twelve miles from the Rosherville power station. This station is equipped as a compressed-air supply station with six turbo-air compressors, each of 4,000 to 5,000 horse-power, driven by direct coupled synchronous motors.

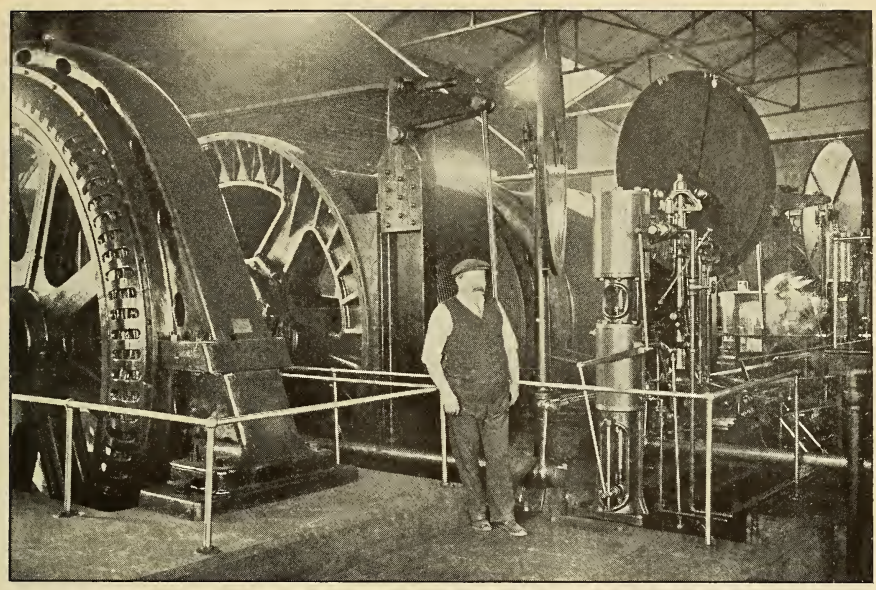
SIMMER PAN STATION

This important station is located nearer to Germiston alongside of an extensive sheet of water known as the Victoria Lake. It is worked in conjunction with the other stations, and has six turbine-driven generators, four of which generate electricity at a pressure of 2,400 volts, increased up to 11,000 volts for transmission to the various mines. The other two sets, however, generate the power direct at the higher required pressure. The turbines are of 4,000 horse-power, the power being delivered by a three-phase current at a frequency up to 50 periods per second.

The steam power here also is supplied by Babcock & Wilcox boilers, sixteen in number, of the marine type, in four rows, in two separate boiler houses. Each boiler has a generating capacity of 20,000 pounds of steam per hour at a pressure of 200 pounds per square inch, superheated to a total temperature of 300 degrees Centigrade. Chain-grate mechanical stokers are used, the cheapest fuel—that of duff or dust coal, from the Middleburg coal field—being used with good results. The switch gear is under remote control, and perhaps the most interesting feature of this station is the fact that it is the centre from which the supply to the whole of the consumers is controlled. On the wall in front of the person in charge is fixed a diagram showing all the different stations. At a glance, by an ingenious contrivance, the diagram shows whether any switch is open or closed, and all the switching can be controlled over the whole system, also the distribution of the load along the different lines and between the generating stations. The result is that at this point perfect control is given of the distribution of electric power throughout the whole of the company's operations, the officer in charge being, in addition, aided by telephonic communication with the attendants, who, consequently, act under direct instructions at all the different stations. The smallest station belonging to the Victoria Falls Power Company at present in operation is that at Brakpan,



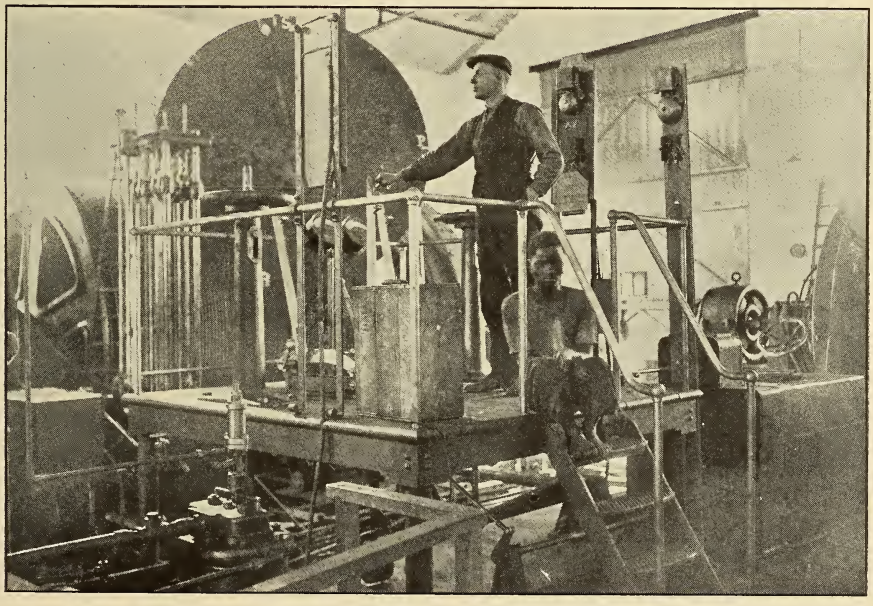
GENERAL VIEW OF BRAKPAN POWER HOUSE



ELECTRICAL HOIST AT BRAKPAN

in the Far East Rand, an old station acquired from the Rand Electric Company and installed at Brakpan in close proximity to the coal. It is mainly used to supply the mines in the immediate neighbourhood, using an overhead transmission line at 10,000 volts. At present it is equipped with two turbo-alternator sets, each of 3,000 kilowatt capacity.

Another important station is in course of erection by the Victoria



CONTROL OF ELECTRIC WINDER AT BRAKPAN

Falls Power Company at Vereeniging, on the Vaal River, about 35 miles due south of the Central Rand; but at the time of writing it is only in its initial stages. It is understood, however, that the scale of operations will exceed even that of the Rosherville station, the most recently constructed and extensive of the different stations belonging to the Victoria Falls Power Company.

To afford an idea of the magnitude of the operations of the Victoria Falls & Transvaal Power Company, Ltd., it may be pointed out that the total debenture and share capital of the concern is six millions sterling. The license obtained from the government allows the company to supply power up to five hundred million units per year. In addition, the company have had placed in their hands the supply of compressed air as granted by license to the Rand Mines Power Supply Company to the extent of six million units annually. The present length of transmission lines extends from one end of the Rand to the other, a distance of more than 50 miles, with over thirty sub-stations, the energy being distributed to these various sub-stations, where it is transformed to 2,000 or 500 volts, as may be required.

The following is the schedule of prices fixed by the Victoria Falls Power Company for the supply of electrical energy to its consumers:

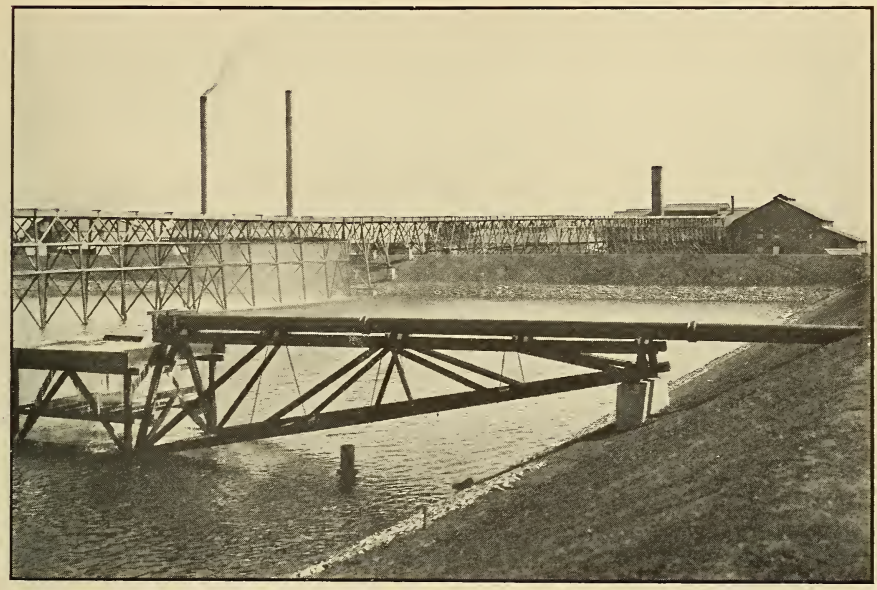
Load Factor, Percentage.	Price Per Unit (Kw.-Hour) from Oct. 1, 1910, to Oct. 1, 1912. Pence.	Price Per Unit After Sept. 30, 1912. Pence.
10	2.512	2.475
15	1.754	1.717
20	1.375	1.338
30	0.995	0.958
40	0.807	0.770
50	0.692	0.655
60	0.617	0.580
70 and over	0.5617	0.525

With regard to the cost of production of electrical energy on such a large scale as that carried on by the Victoria Falls Power Company, the information would be exceedingly interesting; but up to the present this cost does not appear to have been made public.

RANDFONTEIN POWER STATION

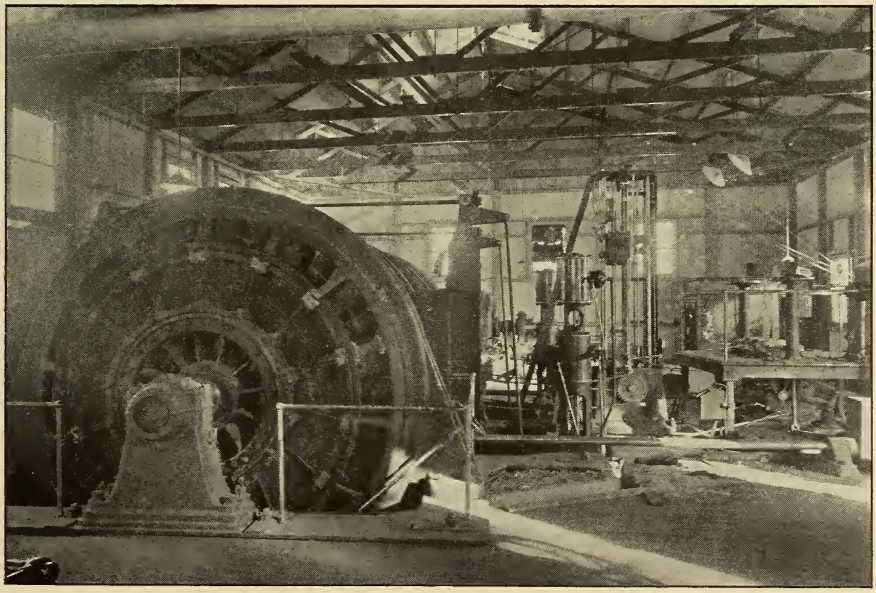
After the Victoria Falls power stations, that at Randfontein ranks second in importance. The decision to use electrical power seems to have been arrived at some five years ago, when it was considered probable that electrical power would bulk largely in and perhaps become absolutely necessary for exploiting the Rand gold reefs to the ultimate depth at which it would pay to work them. At that time deep winding seemed to offer the greatest hindrance to deep mining; and since that date it has been generally recognized that deep-winding difficulties would be far more easily overcome by using electrical power than with any other motive power. The first equipment at Randfontein, however, consisted of only two 1,000-kilowatt sets, but the power generated proved so convenient and satisfactory that it was decided to apply it throughout the whole of the property in place of steam. Now, the Randfontein property is a large one, and practically constitutes a gold field in itself, extending, as it does, a distance of three miles along the outcrop of the reef. The present equipment consists of the two original 100-kilowatt sets, with three 2,000-kilowatt sets and two 6,000-kilowatt sets since added, bringing the total equipment up to 20,000 kilowatts in all. It is probable, however, that, as these mines become further developed and the use of electricity as a motive power extends, further additions to the plant will have to be made.

The steam for driving the plant is generated in twenty-four Babcock & Wilcox land type boilers fitted with chain mechanical stokers and superheaters. The heating surface of each boiler is 4,780 square feet, the working pressure being 160 pounds per square inch, superheated to a temperature of 500 degrees F. The fuel now used was previously con-

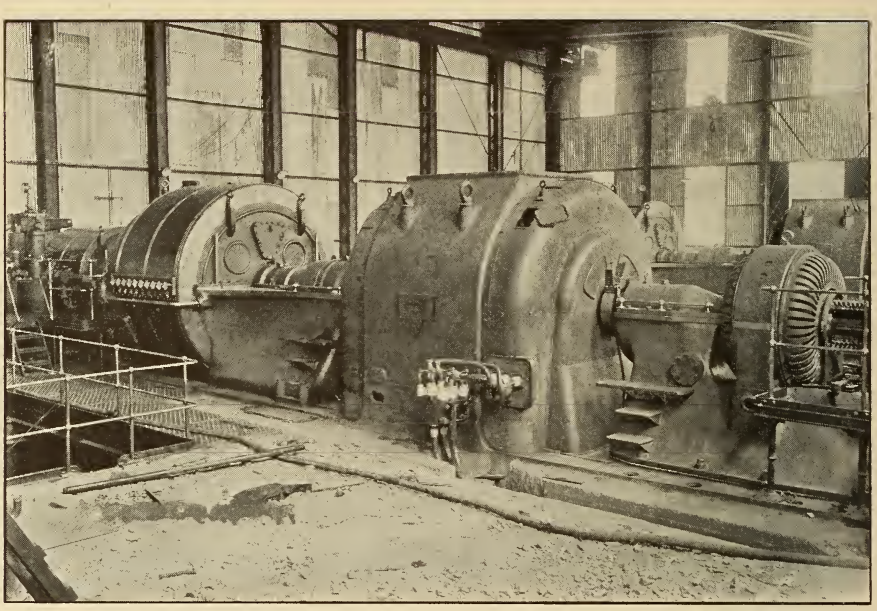


RANDFONTEIN CENTRAL ELECTRICAL POWER STATION

sidered of no value, and was, consequently, conveyed to the waste heaps at the collieries in the Middleburg district of the Transvaal, and costs at the collieries only ninepence to a shilling per ton. Delivered at the boiler bunkers, however, at Randfontein, it costs, owing to the high railway rate, over 10 shillings per ton. It contains 12 to 20 per cent. of ash, and has a theoretical calorific value of 11,500 British thermal units.



ELECTRIC HOIST AT RANDFONTEIN



RANDFONTEIN CENTRAL STEAM TURBINE AND GENERATOR

The boilers are arranged in four self-contained boiler plants, each of four boilers, with economisers, feed pumps and induced draught arrangements, etc., to ensure perfect combustion of the dust coal, a separate chimney stack being provided for each group of four boilers.

The sets are run by steam turbines, the large 6,000-kilowatt sets running at a speed of a thousand revolutions per minute and the smaller sets at a speed of fifteen hundred revolutions per minute.

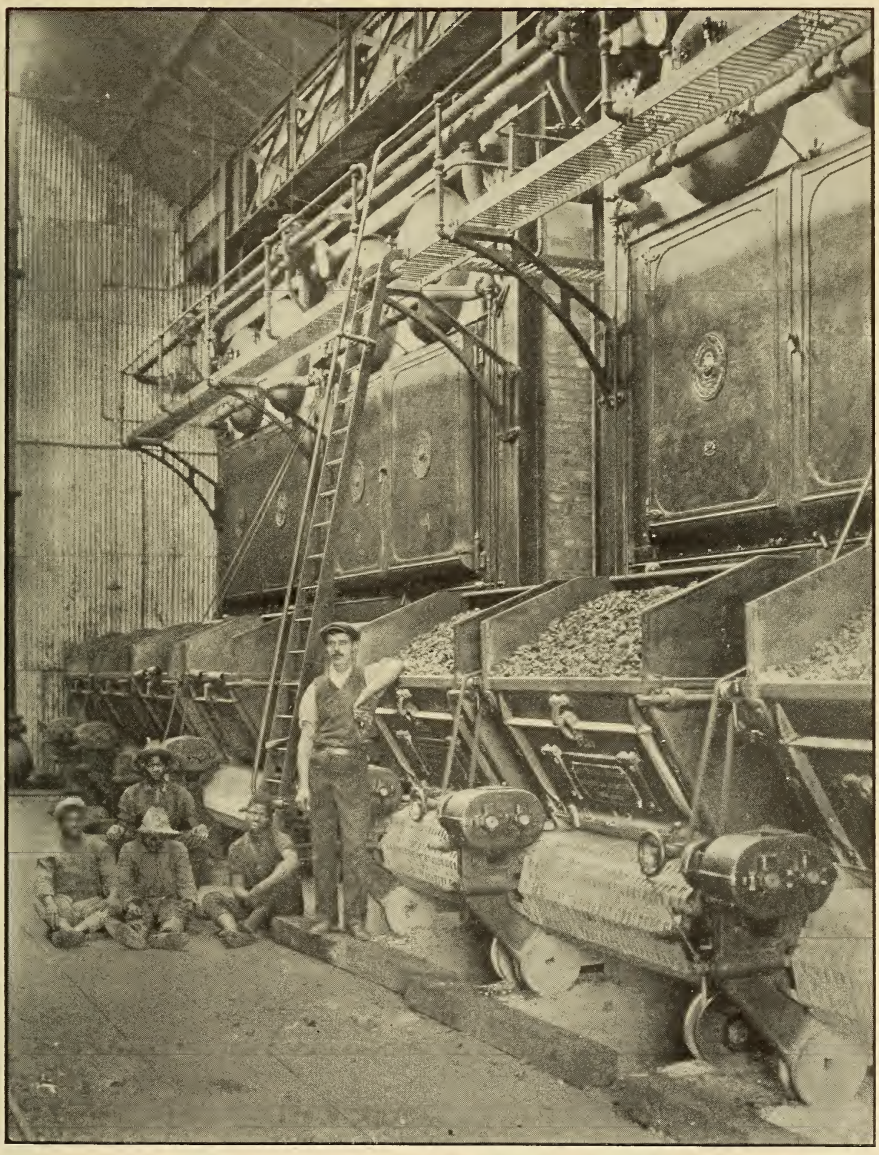
The three-phase current is generated at a frequency of 50 cycles and at a pressure of 6,600 volts between phases. It is reduced for the station motors to 550 volts, and for lighting purposes to 120 volts. There are already more than 30 miles of cable on the property, operating in parallel, laid at a depth of 2 feet 6 inches below the surface of the ground. Lighting is by overhead lines at 120 volts. The total capital cost for the Randfontein power plant to date is given as £312,000, the cost of plants on the Rand being generally taken as double those of the home cost, owing to shipping and railway freights and the high cost of skilled wages in the Transvaal.

With regard to the cost of production, the chief engineer gives the following as the average cost per unit during a month when over five million units were generated: Coal, 0.153*d.* per unit; repairs and maintenance, 0.046; salaries and wages, 0.038; stores consumed, 0.003; office and general expenses, 0.007; total cost, 0.247 pence per unit.

EAST RAND POWER PLANT

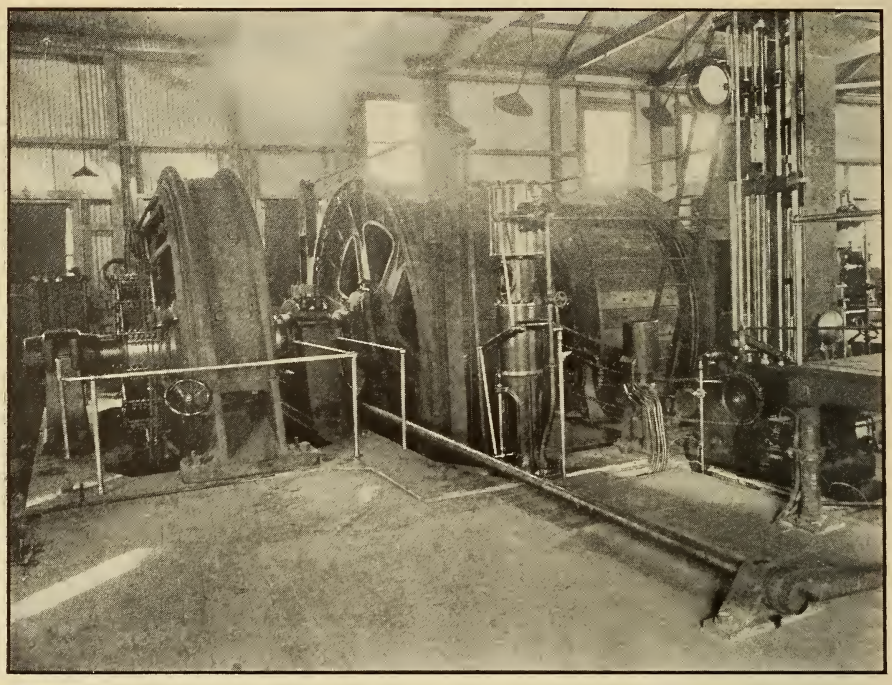
The next important power plant installation is that at the East Rand Proprietary Mines, a group of mines covering an extensive area on the East Rand, and until recently the largest gold producer in the world, a position, however, which has lately been usurped by the Crown Mines, also near Johannesburg, with the Randfontein property, above described, running almost a neck-and-neck race for the honour.

This is one of the oldest power stations erected on the Rand, and at



RANDFONTEIN BOILER HOUSE, SHOWING BABCOCK & WILCOX BOILERS AND CHAIN-GRATE STOKERS

first only small units were installed; but, as in every other case, the power proved so satisfactory and handy, not to say cheap, as compared with steam, that sets of 6,000-kilowatt capacity were afterwards found to be necessary. Here the station supplies three-phase current at 3,000 volts at a frequency of 25 cycles, and it may be pointed out that it was at one of the mines belonging to this group that experiments were first tried in driving the stamp mills by electricity. The cost of production here is not known; but the chairman of the group states that it is considerably lower than they would have been able to obtain it from the Victoria



ELECTRIC WINDING ENGINES AT RANDFONTEIN

Falls Power Company, and that the policy of generating their own power has been justified by the results.

KLEINFONTEIN CENTRAL POWER STATION

This power station at the present time is of similar output capacity to that at Brakpan, the smallest station operated by the Victoria Falls Power Company. It has only been recently erected with the object of ultimately meeting the power requirements, when extended, of the Anglo-French group of mines, consisting of New Kleinfontein Mines, Apex Mines, New Boksburg Mines, Benoni Consolidated Mines and the Rand Klip Mines. Only the New Kleinfontein mine at present is producing; but the Benoni mines may be started before this appears in print, the other mines being in various stages of development, except the New Boksburg mines, which have recently been closed down.

At present the capacity of the plant is 6,000 kilowatts, composed of three 2,000-kilowatt turbo-alternator sets; but in arranging the plant provision has been made and space provided for increasing the capacity ultimately to 20,000 kilowatts should such extensions at any time become necessary.

The boiler plant consists of six Babcock & Wilcox land type boilers, and are probably the largest of that type yet erected on the Rand, as they each have a grate area of 224 square feet, with a heating surface of not less than 7,392 square feet. The boiler pressure is 200 pounds per square inch, the steam being superheated to 500 degrees F. The boilers are arranged in sets of two, with economizer to each boiler, induced draught and Weir tandem feed pumps.

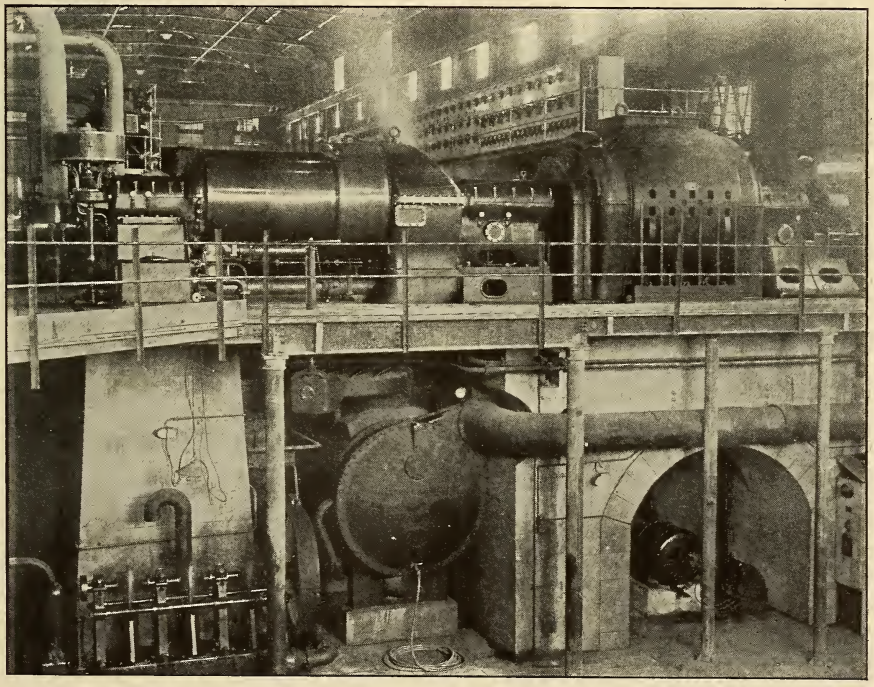
The three turbo-alternators are of the Parsons reaction type, with all the latest improvements, the turbine being capable of driving the alternator so as to give a continuous out-

put of 2,000 kilowatts. The turbines exhaust into surface condensers with a cooling surface of more than 3,000 square feet. Like the station at the East Rand Proprietary Mines, the current is three-phase at 3,000 volts, at a frequency of 25 cycles.

The switches are of the remote solenoid control type and fitted with all the latest improvements. The main transformer room is planned with eight transformer cubicals, of which four are installed at present, with transformers from 3,000 to 20,000 volts. The principal feature of this station is the up-to-date equipment and the design, which is so arranged as to enable the whole plant to be several times extended beyond its present capacity.

APPLICATION OF POWER

As before remarked, electrical power is being used, either directly or indirectly, for all the varied duties connected with power requirements of mining operations on the Rand. Of course, the greatest consumption is in connection with ore reduction, because that is a steady and continuous operation, consuming more power, probably, than any other department connected with gold mining. For milling purposes the use of electrical power is much liked by those in charge of stamp mills, on account of its regularity and uniformity, providing always that the supply of power is ample; but this much-desired condition has not always been attained. The details with regard to the best method of applying electrical power to milling operations do not seem to be altogether agreed upon, and there are several different methods in existence on the Rand. To secure success, however, it is absolutely necessary that the motors be of strong construction and well above the duties required. Automatic lubrication is an advantage, as stamps must be prepared to run without stoppages, sometimes for considerable periods.



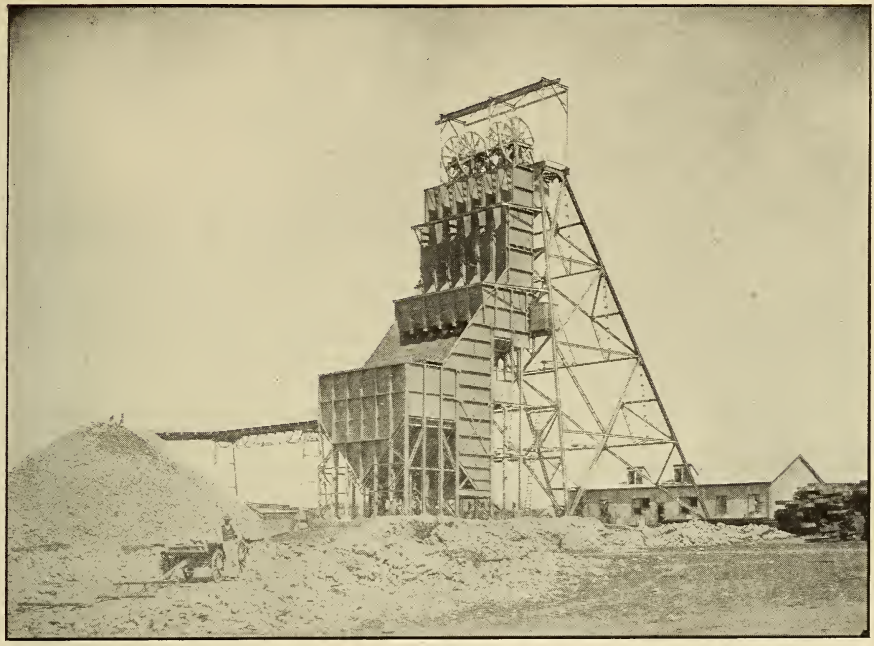
PARSONS TURBO-ALTERNATORS AT THE EAST RAND PROPRIETARY MINE POWER STATION

In a good many instances the stamp mills are driven by slow-speed motors; but in the case of the huge mill at Randfontein, the largest of its kind in the world, the stamps are driven by high-speed motors. Ten stamps comprise one unit, and two of these are driven by motors of 100 horse-power through countershafts. It is found that the actual horse-power required for driving twenty stamps is 92.

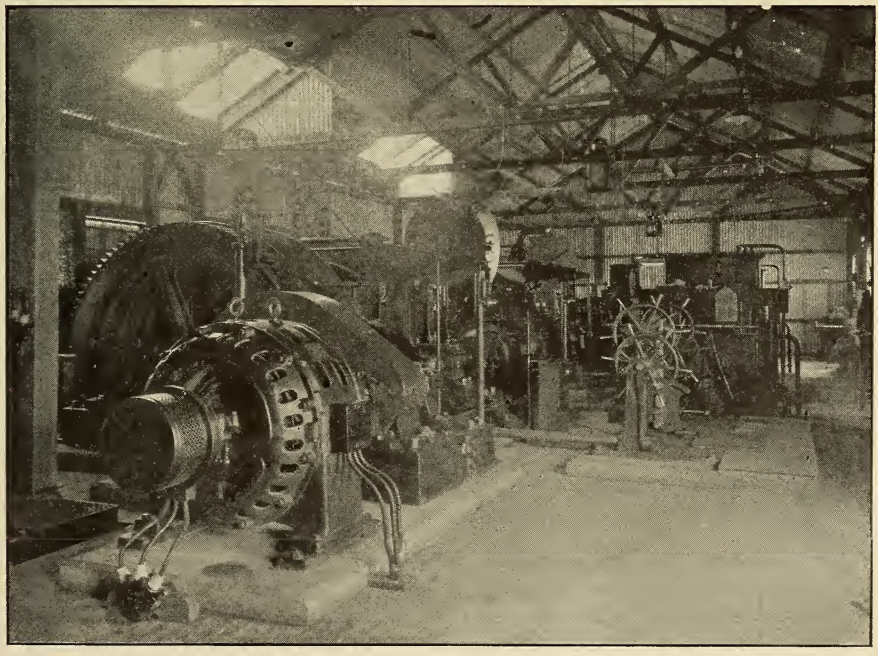
ELECTRIC WINDING ENGINES

It is unknown as yet to what depth mining operations on the Rand will be carried on in the future. So many different factors enter into the question, such as value of the reefs, working costs, underground temperature, etc., that it is impossible to speak definitely on the point; but it may be anywhere between 6,000 and 12,000 feet from the surface. Ten years ago it seemed as though the ultimate depth capable of being reached would depend entirely upon the ability of the mechanical engineers to design suitable plants to wind ore successfully from great depths, and much speculation prevailed upon the subject. Since the application of electricity to winding purposes became an accomplished fact that difficulty seems to have well-nigh altogether disappeared, and the ultimate depth to which mining operations can be taken on the Rand appears to be governed more by the value of the reefs as they grow in depth than by any other factor. At all events, engineers on the Rand now regard the deep-winding problem with every complacency, feeling sure that, by the adoption of stage winding, they will be able to wind the ore from any depth mining engineers can successfully extract it. It seems to be recognized on the Rand that the most economic limit of depth to place on stage winding is in the neighbourhood of 3,000 feet, and already at several of the large amalgamated concerns levels are being constructed at about this depth, so as to form the depth limit to the first operation of stage winding.

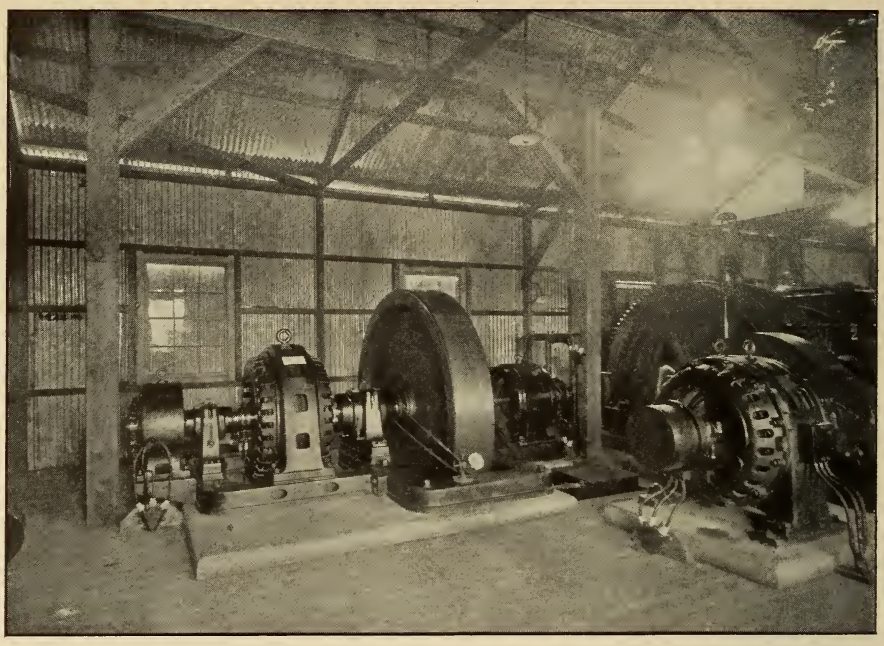
Quite a large number of the old steam winding plants on the Rand have been converted into electric winders, especially where they are of modern design and the change one that can, on mechanical grounds, be recommended. Where the drums are geared, the motors are generally run at a speed of 350 revolutions per minute; but in some cases the drums are operated by motors coupled direct to the driving shaft. The peak loads naturally vary according to circumstances, being as low as 400 horse-power in the smaller mines and as high as 4,000 horse-power in the deep mines, in which winding has to be done from depths of more than 4,000 feet from the surface. The load may seem somewhat high, even where the net weight of ore lifted is approaching ten tons; but it must be remembered that the method of handling the ore underground on the Rand causes unbalanced winding. Of late, however, the necessity of concentrating the work has been at last recognized, and ere long it may be possible to bring balanced winding more into vogue. One of the largest groups, with mines scattered all over the Rand, and that has made, it is understood, satisfactory arrangements for the purchase of its power from the Victoria Falls Power Company rather than generate the power for its own use, has equipped its winding engines with three-phase motors, with liquid rheostatic control; but in almost all the other cases the Ward-Leonard system of control has been adopted. There has, of course, been considerable discussion on the Rand as to the advisability of employing three-phase motors on the very deep shafts and with the unbalanced conditions of winding prevailing on the Rand; but, recognizing this difficulty, electro-magnetic brakes, in addition to the mechanical brakes, have been provided for use in case of accident. Other local engineers, under these



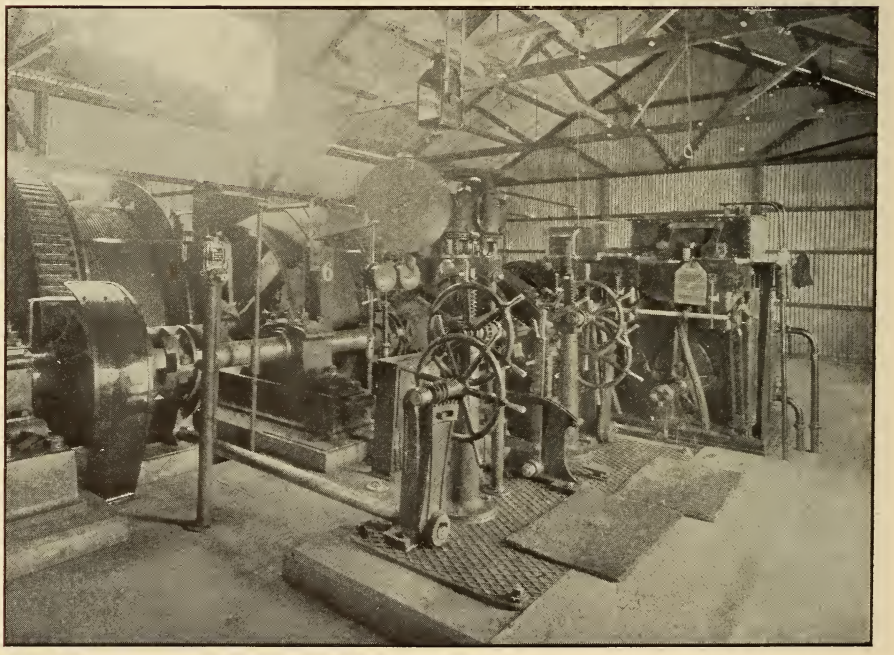
HEAD GEAR AND HOUSE FOR HOIST AT THE CINDERELLA DEEP MINE



WESTINGHOUSE MOTOR ATTACHED TO WINDING ENGINE AT THE CINDERELLA DEEP MINE



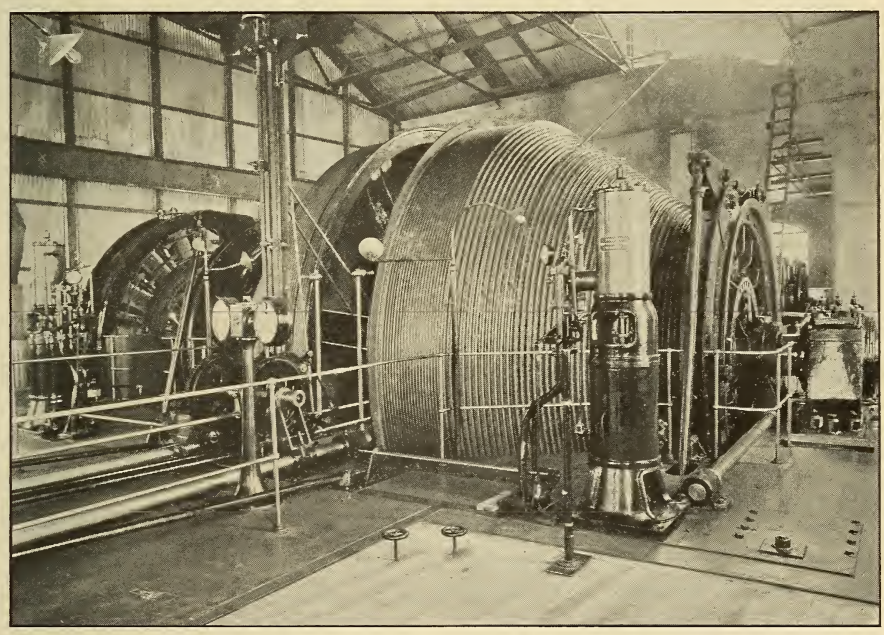
VIEW OF HOIST, SHOWING WESTINGHOUSE FLY-WHEEL GENERATOR AND WINDING MOTOR AT THE CINDERELLA DEEP MINE, TOBURG, S. A.



GENERAL VIEW OF ELECTRIC HOIST AT THE CINDERELLA DEEP MINE, SHOWING OPERATOR'S PLATFORM

trying conditions, have deemed it best to adopt the Ward-Leonard system.

A somewhat interesting comparison was recently made between these two systems of winding by the chief electrical engineer of the Randfontein group of mines in a paper recently read before the local Institute of Engineers. He stated that, of course, the three-phase was the most simple and its first cost less expensive; but the first or capital cost only. As regards the running and maintenance expenses, the latter would, perhaps, be about the same in both methods; but he calculated that, making the cost of power at 3*d.* per unit and basing the estimate on an ordinary day's work with both systems, the three-phase hoist would cost in power £9 18*s.* 11*d.*, whilst the Ward-Leonard system would cost for the same duty only £8 18*s.* 5*d.* per day,



ELECTRIC HOIST AT THE CINDERELLA CONSOLIDATED MINES

after going fully into the merits of the two systems the Ward-Leonard system had been adopted at Randfontein, because in that system the strain on the power station was more uniform, the control more efficient, and in the long run it was probably more economical than the three-phase system. He stated that the tender for the supply of the three-phase winder was £2,000 cheaper than the Ward-Leonard, and when erected the total cost of the three-phase would be only £8,300, as compared with £10,700 for the Ward-Leonard, this, of course, being for which fact he considered, along with the superior operating advantages possessed by the Ward-Leonard method, would more than make up in the long run for the difference in capital costs.

It is interesting to notice with what ease the winding enginemen on the Rand have changed over from steam and become accustomed to electric winding plants. Not a single accident appears to have been chronicled as the result of the change, and, what is more, the men have expressed themselves in favour of the electric winders. The only drawback

has been experienced in the winter months, when the engine rooms are cold as compared with steam winding rooms; but to overcome this inconvenience radiators, or some convenient methods of heating the winding engine rooms, have been adopted. On the other hand, in the summer months the electric winding rooms will be cool, and thus tend to make up, perhaps, for the other disadvantages.

COMPRESSED AIR

Probably the next important use to which electricity has been applied in connection with mining operations on the Rand is that of compressing air. It may seem strange to some engineers that compressed air should be so largely used on the Rand when such a handy form of motive power is so readily available as electricity. The fact is, that all the machine drills underground are operated by compressed air, and the exhaust air comes in handy for ventilation, which, in addition to natural ventilation, in a good many instances is the only method of ventilating the mines practiced on the Rand. Lately ventilating fans have been more extensively introduced into the gold mines on the Rand; but, nevertheless, it may be said that mine ventilation, even by the aid of these fans, leaves much to be desired.

Firedamp or explosive gas is, however, conspicuously absent, ventilation being required only to remove the foul air, dust, and fumes generated during mining operations, so that the use of electricity underground possesses none of the terrors felt in coal mining, where explosive gas is so prevalent and dangerous.

As already pointed out, the Victoria Falls & Transvaal Power Company are also producing compressed air for underground consumption on an extensive scale. Both at Rosherville and near the Robinson Deep Mine stations the air is compressed to more than 100 pounds per square inch, being principally delivered to the Eckstein group of mines. These compressors are the largest of any yet erected on the Rand; but, nevertheless, they have not been able to fully comply with the whole of the requirements of the mines. They are of the rotary type and fitted with water-jackets. These motor-driven rotary compressors have synchronous motors of 4,000 to 5,000 horse-power, and are started up by auxiliary induction motors with gearing and clutched to the compressor shaft. At Randfontein the air is compressed to a pressure of 80 pounds per square inch by synchronous motors, also with auxiliary starting gear, where also it is reported that the synchronous motors have given every satisfaction, being started by a 100 horse-power induction motor geared to the shaft with striking gear. The dimensions of the compressors are: First-stage cylinder, 42 inches diameter; second-stage, 25 inches, and length of stroke, 3 feet. The weight of the mechanical parts is 80 tons and that of the electrical parts 43 tons, so that the total net weight of the parts is 123 tons. The method of control is by allowing air from the discharge chamber to return to the cylinders during the suction stroke, a method which has proved satisfactory. These compressors have been in operation at Randfontein for over a year, and have, therefore, passed the experimental stage.

HAULAGE

For a long time ordinary motors have been used for haulage purposes above ground, varying from 20 to 80 horse-power, and, of course, have answered well. Underground, however, few mechanical haulages of any kind have been installed; and even to-day most of the ore in the underground levels is trammed to the shaft by Kaffirs, a system quite double as costly as mechanical haulage would be under suitable conditions. The explanation is, that mechanical haulage needs comparatively straight drives; but on the Rand gold mines

ELECTRIC MOTOR DRIVING STAMPS AT CROWN MINE

the levels have frequently to twist about to follow and pick up the reef. Now that mining operations, however, are being conducted on a larger and more concentrated scale, it is becoming recognized that straight, wide drives, equipped with mechanical haulage, are, on economical grounds, necessary, and in several instances either mechanical or electrical haulage systems are being installed. The first to adopt electrical haulage underground was the Geduld mines, where it is said to give every satisfaction; and before long undoubtedly a good deal of the transport of rock underground will be carried out by underground mechanical haulage, in which electricity will play a prominent part. Of late, on the surface it has been found advisable, especially where operations are conducted on a large scale, to adopt the standard South African railway gauge of 3 feet 6 inches in place of the narrow-gauged tramways, and to equip this standard gauge line with electrical locomotives. This step has been adopted on such important properties as the Crown and City Deep mines for the purpose of conveying ore from the mine to the mill after it has undergone the process of crushing, and, moreover, has been found to work well. These electric locomotives weigh about 50 tons, and are of 300 horse-power capacity, developed by two three-phase motors, each of 150 horse-power. Each locomotive unit is provided with air compressor and vacuum pumps, electrically driven, and is a complete locomotive in itself; so much so that it can be uncoupled, and so deal with half the load usually hauled by the compound locomotive should such a proceeding from any cause be found necessary.

There are numerous other duties on the Rand being carried out by the application of electrical power to mining operations, prominent amongst them being that of pumping water from the shafts and underground works. Electrical power under the mining conditions prevailing on the Rand is so handy for conveyance to points underground where it happens to be needed, and when there works so smoothly and well, without

any of the inconvenience attending the conveyance and use of steam and compressed air, that for a long time it has been in use on the Rand for pumping and lighting duties. Of late, too, it has been called into use for driving ventilating fans underground, and in this respect its use promises to be as helpful in allowing mining operations to be carried on to great depths on the Rand as in the case of deep winding.

It must be recognized that the Witwatersrand gold field possesses many advantages for the economical generation and application of electrical power to its mining operations. Coal of fair quality is cheap and abundant, the dust used in the steam boilers being supplied at from sixpence to ninepence per ton at the collieries, while water, too, is fairly abundant. The gold mines extend in one continuous line from Springs to Randfontein very similar to a huge coal field, thus aiding economical distribution, and resulting in a more extensive application of electrical power to mining operations in one form or another than in any similar sized area in the world. The use of electrical power on such an extensive scale on the Rand is still, however, in its infancy. Its application has not been altogether unattended with disappointments, but with a distribution line over a hundred miles in length, with voltages as high as 40,000, and in a country noted for its thunderstorms, the Victoria Falls Company have indeed done well to keep the supply as uniform as it has done up to the present. It is also clear that the splitting up of the supply between four generating stations, but so linked together as to make their output available at all points wherever needed, reduces, with sound generating plants and other equipment, the risk of a general dislocation of the power supply to a minimum.

THE SELECTION OF ELECTRICAL APPARATUS

CONDITIONS GOVERNING CAPACITY

By H. M. Phillips

ONE of the first, and in some respects the most difficult, as well as the most important, of the problems that confront the purchaser of electrical apparatus is the determination of the proper capacity to install. Overloading is by far the most frequent cause of failure of electrical power apparatus. This fact is well known to all engineers and manufacturers of electrical machinery, and as the purchaser, if not himself an engineer, usually takes the advice of one, or of the manufacturer's representative, he is rather apt to purchase more capacity than he really needs. At first glance, this does not appear to agree with the statement that overloading is the chief cause of trouble, but it must be remembered that the percentage of trouble-givers is rather small and that in many cases the overloading is caused by service not contemplated at the time of the original purchase. There, of course, remain a few cases in which mistakes were made at the time of purchase.

The purchaser is generally anxious to obtain apparatus that will give the minimum amount of trouble after installation; and, unless money is particularly tight, is willing to pay something extra to feel safe in this respect. The manufacturer naturally likes to sell at least as large an order as is consistent with his idea of fair dealing; and both manufacturer and engineer know that, although the customer may grumble at high first cost, this will soon be forgotten after everything is running smoothly, but that a breakdown will probably throw lasting discredit on both. In case of an argument, the man who stands out for "ample" capacity has a seeming advantage; it sounds well for one to say that he "likes to be on the safe side"; to speak of the errors that he has seen made and their disagreeable consequences, etc. We all want to be on the "safe side"; we know that it does not pay to "take chances," but we must draw the line somewhere.

Various tables and formulæ will be found in hand-books and technical publications for determining the power required for various purposes. These are undoubtedly helpful if intelligently used, but are apt to lead one astray if he has not had practical experience along lines similar to the one in question. In addition to the above, so much depends upon sound judgment, the "common sense" of engineering, that it may be considered the most important factor of all. The purpose of the present article is to assist the possible purchaser in the application of the latter qualification by pointing out some of the difficulties that he will probably encounter.

Perhaps the simplest case will be the application of a motor to a pump that is to be operated continuously against a fixed head for six hours a day or longer. It is easy to figure the power required to drive the pump, and a continuous-duty motor of the proper horse-power should be ordered. But suppose the figures call for 8 horse-power; the only commercial ratings applicable are 7½ and 10 horse-power. Can we take a chance that the smaller size will suffice, or shall we be on the safe side and order the larger motor? The difference in price may be more

interesting if we assume a larger horse-power or that a large number of motors are to be purchased for the same duty. It is, of course, very reprehensible to put a 7½ horse-power motor on an 8 horse-power job; you cannot blame the manufacturer if the motor gives trouble, and the first intimation that the motor is not equal to the task is likely to be the burning out of its windings, which will necessitate expensive repairs before the motor can be used again for any purpose. There is practically no ground to stand on if such an installation is recommended and it fails. If this is not sufficient to cause the use of the larger size, let the possibilities of the case be considered.

The *actual* capacity of the motor is reached when its windings approach closely to a temperature that, sooner or later, will so weaken the insulating material that it fails to perform its function, with a burn-out as the result. In some cases the capacity may be limited by the tendency to spark at the commutator, but with a well-designed modern motor these are so rare that they may be considered as negligible. Now, for all-round satisfactory service, the motor must be able to deliver its rated horse-power during hot weather and in warm locations—say with the surrounding air at 100 degrees Fahr.—without the windings reaching a dangerous temperature. If the motor is to be so situated that the temperature of the surrounding air will never exceed 70 degrees, the entire motor will be approximately 30 degrees below the danger line when running at its rated capacity, and can, therefore, carry safely an overload sufficient to increase its temperature 30 degrees without exceeding the limits that have been provided for in its design. Just how much increase in capacity this would give cannot be stated, but it will be sufficient to allow safely the 8 horse-power load. A strong draught of air will also tend to keep the motor cool, and so allow it to be run above its rating. On the other hand, if the motor is to be run in an exceptionally warm place or in one in which there is little chance for ventilation, it is wise to use a motor with a rating slightly higher than the required horse-power.

Some motors are considerably underrated, but one must have an intimate knowledge of the practice of the manufacturer from whom the motor is obtained in order to take full advantage of the fact. The salesman may state that his motors are underrated; but, as his firm will not stand behind the statement, some risk is taken by accepting the salesman's word, unless one is very sure, not only of his truthfulness, but of the accuracy of his knowledge. The 7½ horse-power motor of a certain make which is designed to run at 220 volts and 1,000 revolutions per minute may be underrated and fully capable of running at 9 horse-power; it does not necessarily follow that the 5 or the 15 horse-power motor of the same make is underrated, or even that the 7½ horse-power of another speed or voltage is underrated; neither does it follow that a similar motor of another make is capable of going above its rated load. It is safe to say that anyone manufacturing a line of motors of standard rating will have some that are very considerably underrated and some that are quite closely rated. As a rule, the manufacturer sticks to the standard rating and claims that it is accurate for all of his motors; he will not guarantee any of them to carry more than their rated load. The writer has, however, seen two motors turned out by a well-known manufacturer that were absolutely identical in all respects save that one was rated at 7½ and the other at 8½ horse-power.

Before making the final decision as to the rating of a new motor it is always desirable to look a little into the future. Is it possible that the pressure on the pump may be increased or that the pump may be speeded up in order to obtain more

water? In either case more power will be required, and it must be decided whether it is wiser to provide for this at the start or to install a new motor when the occasion arises. If the smaller size is installed and operates satisfactorily, it is probable that the heavier load will be put upon it, provided that the increase is not very great, when the time comes; and it is quite probable that the result will be another motor burnt out through overloading.

As the heating of a motor, which limits its capacity, is gradual, it is evident that its rating may be increased if it is to run continuously for short periods only. If direct current is used and the pump is to run for two hours per day, a motor with an "intermittent duty," or two-hour rating, may be purchased at a considerably lower figure than for continuous duty. This plan may be carried further and a thirty-minute rating obtained still cheaper. In either case the motor will be overloaded, and may burn out if it is run too long. The run may be increased to some extent if the motor is not working up to its full capacity, or it may safely be run a little above its rated capacity for a shorter period than that specified, although it is possible that there will be trouble with poor commutation in the latter case. The alternating-current motor heats more rapidly than the direct-current motor, and, therefore, is not given a two-hour rating; it would be practically the same as for continuous duty. If desired, however, one may be purchased with a thirty-minute rating. If the pump is to be used to keep a supply tank filled, it is quite probable that it will run for short periods a number of times during the day. It will not have time to get entirely cool between runs, and, therefore, if closely rated, will be overheated if the runs are of two hours' duration each. Shorter runs aggregating considerably over two hours could, however, be made without danger.

When a motor is used to drive a single machine tool it is generally desirable to have it as small as is consistent with safety, on account of the saving in space, as well as in cost. The tool may be in use for eight or ten hours a day, but will probably never carry a heavy load continuously for that length of time. As a rule, the load is variable, and is light for a considerable portion of the time, and there are frequent shutdowns of short duration. For this reason a motor with a two-hour rating is generally installed with a machine tool. There are many more or less trustworthy formulæ and tables for determining the power required by a machine tool under various conditions. It is frequently possible to determine it by experiment, which is, of course, the best method; but with all this there is still opportunity to display some judgment in the selection of the motor. One type of tool may be run at or near its maximum load whenever it is in use; another may use its maximum power only at infrequent intervals and but for a few minutes at a time. In this connection sight should not be lost of the fact that most motors with a two-hour rating are guaranteed to carry a 25 per cent. overload for thirty minutes without injury, and 50 per cent. momentarily, or sometimes for three minutes. These overloads may be applied immediately after a two-hour run under full load; if they are applied while the motor is cool they may be maintained without danger for a longer time than specified.

Consider next a line shaft driving a number of machines. This shaft will run all day with a fairly constant load, so that a continuous-duty motor is evidently required. In some instances all of the machines are likely to be in practically continuous use on a definite class of work, and the power required under this condition will never be exceeded, which makes a very simple case. Again, it may be almost a certainty

that all of the machines connected to the shaft will never be in actual use at the same moment, and the individual machines are of the type whose loads vary greatly under various working conditions. There is also a possibility that a few extra machines will, sooner or later, be crowded in on the same shaft. Is there any possible rule that will apply to these conditions? It may be comparatively easy to estimate the maximum power required for each machine; add all together and then increase the total by 10 or 25 per cent., and so be on the safe side; but this method is hardly conducive to economy. The maximum load that is ever likely to occur should be estimated, as well as the time that it may be maintained; for the continuous-duty motor is guaranteed to carry a 25 per cent. overload for two hours and a 50 per cent. overload for three minutes.

With an alternating-current system it is frequently necessary to use transformers. The same principles apply as for motors. The transformer is usually sold with a continuous-duty rating only, but is guaranteed to carry a 25 per cent. overload for two hours after having attained constant temperature at full load. As a matter of fact, the modern transformer is capable of carrying very heavy overloads for short periods, especially if it is cool when the overload is applied. These facts should enable comparatively small transformers to be used in connection with intermittent-duty motors. On the other hand, the fact must not be overlooked that, although the capacity of a transformer is generally spoken of and sometimes listed as a certain number of kilowatts, the true capacity is expressed in kilo-volt-amperes (K. V. A.). To illustrate; take the case of a 25 horsepower motor. Its full-load output is $25 \times 0.746 = 18.65$ kilowatts. The motor may have an efficiency of 85 per cent., in which case the input of the motor, or transformer output, will be $18.65 \div 0.85 = 21.9$ kilowatts. The alternating-current motor, however, always has a power factor, which does not affect the efficiency, but does increase the number of amperes required by the motor. If it is assumed that the above motor has a power factor of 80 per cent., the input in kilowatts will remain the same, but the kilo-volt-amperes will be $21.9 \div 0.80 = 27.4$, which figure must be used in determining the capacity of the transformers. Two or three transformers are generally necessary for an alternating-current motor running on a two or three-phase circuit, in which case the capacity figured is divided by the number of transformers to obtain that of each transformer.

The case of a transformer, or group of transformers connected together, to supply a number of motors is practically the same as that of a motor driving a line shaft. For factory lighting it is well to have the transformer of a rating fully equal to the load, due to all the lights that are or may be connected on its circuits. If the factory is to be run all night, it is quite probable that practically all of the lights will be burning for that length of time, and the number of lights installed has a habit of increasing to a surprising extent. Some dark corner or some new kind of work is being carried on that calls for one or two additional lights—not many at a time, but gradually making a total worth considering. On lighting service the regulation is a matter of considerable importance, and this will be better if the transformer is not heavily loaded. If incandescent lights only are used, the power factor will be practically unity—the kilowatts and kilo-volt-amperes will be the same. Arc lamps introduce a "power factor" for which proper allowance should be made.

The modern tendency is toward an increase in the number of motor units. If each individual machine is not equipped with a motor they are

arranged in small groups, driven by a short line shaft. Long lines of shafting and heavy belts are becoming things of the past. This undoubtedly adds to the expense of installation, of equipment, and to motor maintenance; but is justified by the superior light and cleanliness resulting from the omission of belts, the better control of individual machines, and the economy of power by cutting wastes on machines that are not in actual use. Transformer practice works in the opposite direction. Formerly the tendency was to use small units. In some localities there may still be seen small transformers on the wall of nearly every house in which lights are installed. The modern, and undoubtedly the better, plan is to use as few transformers as possible. Twenty houses in the same vicinity might each require a 2-kilowatt transformer to supply its lights. A 40-kilowatt transformer may be purchased much cheaper than twenty twos, but the 40 will be unnecessarily large. It is quite probable that on some occasions all the lights in an individual house may be in use for a considerable number of hours, and the individual transformer must be able to supply such a demand; but it is perfectly safe to say that this will never occur with all twenty houses at the same time, and it is, therefore, unnecessary to provide a transformer for that contingency. Moreover, the maximum load, whatever it may be estimated, will probably be of not more than two hours' duration, and the transformer is guaranteed to carry 25 per cent. overload for that time. The large transformer has a very decided advantage in efficiency; even if a 40-kilowatt were installed, the lost power would be much less than with twenty of 2 kilowatts. Transformers may be purchased of enormous capacity, and a single unit might be obtained that would meet the lighting requirements of an ordinary city; but the total cost of wiring increases quite rapidly as the number of transformers used to cover a given area is diminished. To determine the size of a transformer unit it is, therefore, necessary to balance the saving in transformer cost and efficiency against the increased cost of wiring. This problem appears when the transformers are used to supply current to motors scattered about a large manufacturing plant, as well as in lighting a city. In factory practice, and in public service as well, it is advisable to use separate transformers for lighting and motor service. The heavy fluctuations in current caused by starting motors or by varying loads are apt to cause a disagreeable flickering of the lights; this, of course, means considerable additional expense, which, in some cases, may not be justified by the gain in lighting efficiency.

Although nearly any individual manufacturer—in fact, nearly all manufacturers—will make the same temperature guarantee for all ordinary sizes of transformers, some sizes have a much larger temperature rise than others, and are, consequently, less able to carry overloads. Not only is a guarantee made for full load, but also that the two-hour overload of 25 per cent. shall produce an additional rise not to exceed a given number of degrees, the same for all sizes. A very small unit—say 2 kilowatts—will carry this overload indefinitely, with very little, if any, increase in temperature over that obtained at the end of two hours; while a larger unit would continue to increase in temperature for several hours if the overload were continued. In some instances, generally with the smaller sizes, the manufacturer is obliged to give a rating that will enable him to meet the usual efficiency and regulation requirements. Such a transformer may run much cooler than the guarantee, which is the same for all sizes, and, therefore, be able to safely carry a continuous overload with efficiency and regulation below the guarantee.

With at least one well-known manufacturer the difference between the 7½ and 10-kilowatt transformer is only in the size of the outer case. This does not mean that the 7½ could safely be brought to do the work of the 10-kilowatt, for the larger case gives greater radiating surface and allows the transformer to be operated at the specified temperature limit, which would otherwise be exceeded. It does mean, however, that the 10-kilowatt will run fairly close to the specified temperature limit, while there is considerable margin for the 7½; it also means that the 7½ is better able to carry a heavy overload, expressed as a percentage of the full rated load, for short periods, and that the regulation, and probably the efficiency, is better than with the larger rating. Cases like this may account for the differences of opinion that are expressed as to the merits of certain apparatus; the purchaser of one of the 7½-kilowatt might have more to say in favour of such an apparatus than the man who has bought a 10-kilowatt.

Although so many exceptions will be found that it cannot be laid down as a rule, the probabilities are that a small transformer will be as safe, or safer, on overloads of long duration as one of larger capacity; but that the larger sizes are better able to carry very heavy overloads for short periods—say 15 to 30 minutes—especially if they are comparatively cool when the overload is first applied.

The case of a generator for ordinary service differs in no essentials from that of the transformer supplying a large number of houses or motors. Like transformers or motors, they are guaranteed to carry full load continuously without exceeding the standard temperature rise, and to then carry a 25 per cent. overload for two hours without injury and without exceeding a specified temperature rise. Certain sizes will be found to approach the specified limits very closely, while others may have a large margin of safety. As a rule, the manufacturer will guarantee nothing but the standard specifications, and the purchaser has little opportunity to obtain information; he will be compelled to go by the manufacturer's rating, and can tell only from actual experience if he has obtained a better machine than called for by specifications.

If the generator were given a capacity equal to the total of the apparatus that it has to carry there would be in nearly every case a great excess over the actual power required. The load is, however, pretty sure to be increased by the installation of additional apparatus from time to time, and a proper allowance, neither too great nor too small, should be made for such increase after estimating the power that will actually be required under the original running conditions. Except in very large installations, the present tendency seems to be to install a single generating unit of sufficient capacity to meet all requirements; with the same load a single unit gives greater efficiency and less operating expense than two or more smaller ones; and, as a rule, the large units seem less likely to give trouble than the small. The advantages of having two units, however, may lead to their installation in some cases. When the load is light, one of the units may be shut down and the other operated more economically than a larger unit on the same load, and, in case of a breakdown, one unit may be made to carry the most essential parts of the system until the other is repaired. In most cases it will be advisable to have proper space allowed for the installation of an additional unit when the growth of the business requires it.

If an alternating-current system is used, it must be remembered that, like the transformer, the true rating of the generator is in kilo-volt-amperes, and a proper allowance made for the power factor of any motors that it will have to carry.

SOME INTERESTING CASES OF SHAFT SINKING

By John S. Franklin

AN interesting case of unwatering a flooded shaft occurred in England a few years back. In the South Staffordshire district the coal often lies at some considerable distance below the surface. This of itself is not of any especial importance. What is of importance is that between the surface and the coal difficult water-bearing strata may be encountered. In the immediate vicinity of the Littleton collieries great beds of pebbles occur. These are extensive and deep. Thus, in one location the pebble beds are about 320 feet thick; in another, about 360 feet. The pebbles are elongated and thoroughly rounded. These strata afford an abundant supply of water. In fact, a Mr. T. H. Bailey tells us, several pumping stations of the local South Staffordshire water works are situated within a few miles of Littleton colliery, whose coal lies below them. At this location it is impossible to reach the coal without solving the water problem presented by the pebble beds.

As far back as 1876 operations were begun with a view of sinking two 15-foot shafts through beds of pebbles then known to be 320 feet thick and to be heavily watered. No. 1 shaft was bored to a depth of 420 feet. The water was reduced to a point where the depth remaining amounted to only 82 feet. The water thereupon broke in suddenly. This shaft was lost. The boring of Shaft No. 2 was continued to a depth of 438 feet. This shaft was completely unwatered, but a sudden inrush of water compelled the workmen to flee without accomplishing the recovery of the tools and materials. This flooding occurred only a short time previous to the loss of Shaft No. 1. For sixteen years shafts were abandoned. It was then determined to attempt the recovery of Shaft No. 2. This hole, it was thought, might now be cleared of water largely because it had already been successfully unwatered.

Pumps suitable for the work of unwatering were selected. The size and weight of the two pumps may be roughly judged, perhaps, from the fact that the steam cylinder of each had a diameter of 21 inches and that the stroke was 24 inches. Each pump had a capacity of 350 or 400 gallons per minute. The delivery pipe was 8 inches in diameter; the steam and exhaust pipes were each 4 inches in diameter. All were of steel. They were carried on stand pieces located on the pump itself. The sinking of these pumps, with their equipments of pipes, would be an increasingly arduous undertaking as the depth increased. By the time a depth of 400 feet would be reached the load would have become a very considerable one.

Over the mouth of the shaft a very strong sinking frame was put up, which had not only the duty of supporting the two pumps and their accessories, but also that of carrying the pulleys for the capstan and winding ropes. Each pump, together with its pipes, was supported by a pair of heavy chains made of long links. The diameter of the material entering into the chains varied in different sections. For one-third the whole length the diameter was 1½ inches; for the second one-third, 1⅝ inches, and for the last third, 1⅞ inches.

Each chain weighed about 8 tons. When a pump would reach the bottom the weight supported at the mouth of the shaft would, accordingly, be 16 tons, in addition to pump and pipes.

The pipes were supported laterally by means of wooden cross-stays. These were secured by bolts to the long links of the two supporting chains. The nuts on these bolts were locked. The stays were placed, perhaps, 30 feet apart. Clip bolts were used to secure the pipes to them. Suitable clearance was allowed with these in order to provide for expansion and contraction.

At the top two long screws, each 20 feet in length and 4½ inches in diameter, were arranged to take care of each [illegible]. Suitable shackles were employed to [illegible]h the chains to the screws. Large nuts received the screws and effected, by their rotation, the slow movement up or down of the screws and their heavy loads. Ball bearings were arranged between the nuts and their supports. Power for turning the nuts was supplied by vertical engines having cylinders of 7 inches diameter and having a 10-inch stroke. A set of engines was devoted to each pump and its pair of hoisting screws. A worm-and-clutch gearing was so arranged that the two screws of a pair could be operated singly or together. The pitch of the screws was ½ inch. The power available was competent to move vertically a load of fifty tons at the rate of 6 feet per minute. Apparently, the screws could be operated 15 feet per trip. Steel girders were arranged at the surface at either side of the chains. When the screws had been operated through their working length, or when for some other reasons it was desired to relieve them temporarily of their load, these girders became the supports of the steel rods, which would be passed through the links. The screws could then be rapidly run back to a position enabling a grip to be taken of the chains at a new point.

It will be remembered that there were two shafts, both flooded. They were pretty close together, the distance being about 126 feet, and the water in each was apparently at about the same level—66 feet below the surface. It was expected that the procedure of unwatering Shaft No. 2 would draw water out of Shaft No. 1. But this expectation was not realized to any especial extent. Continuous operation was now begun, the two pumps relieving each other. In three weeks a point only 9 feet from the bottom was reached. The inflow of water had amounted to 150 to 200 gallons per minute. The water level in Shaft No. 1 had been reduced only 3 feet. The unwatering of Shaft No. 2 was entirely successful.

It was probably this success which induced the effort to deal with No. 1. The arrangements for raising and lowering the pumps were essentially the same as with Shaft No. 2. Apparently the pumps used at the beginning were the same as before. In four or five days after pumping was begun the water level had been pushed down to 215 feet below the surface. But the inflow was now about three times what it was at the same level in Shaft No. 2. To provide for the more severe conditions, two additional pumps of about the same capacity were installed. In ten days after the third pump began operations the water level was brought down to 305 feet below the surface. The inflow seems to have been 600 gallons per minute at this stage. But this inflow continued to become greater. The top of the central column of 4-inch piping was reached. Finally, the fourth pump was started. The water level was pushed down to 347 feet. The inflow had now increased to 1,000 gallons per minute. The speed of the pumps was now up to 72 strokes per minute, and 1,800 gallons per minute were now being withdrawn. The capacity of the pumping plant had now been pushed to about its

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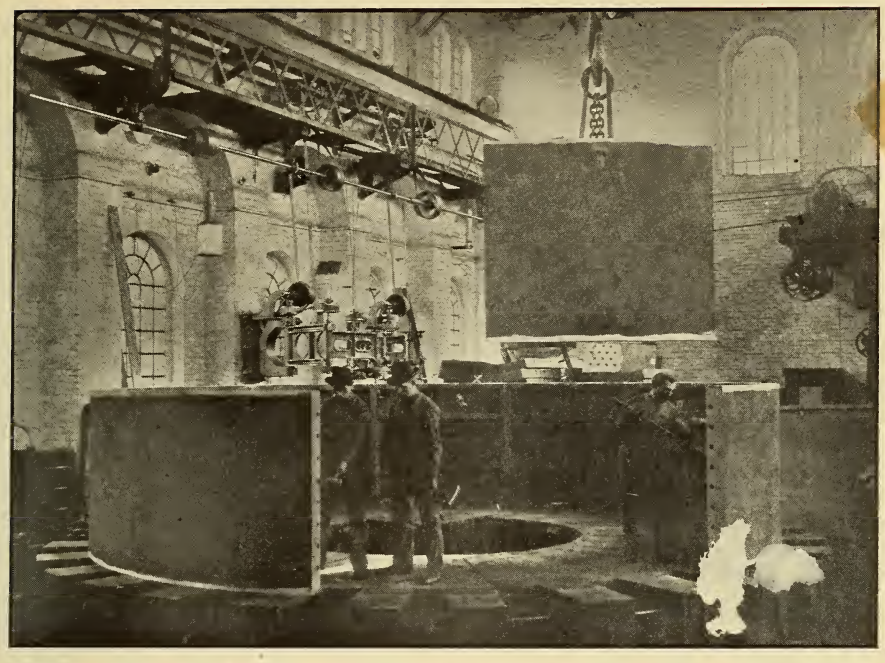


FITTING CAST IRON TUBBING RINGS

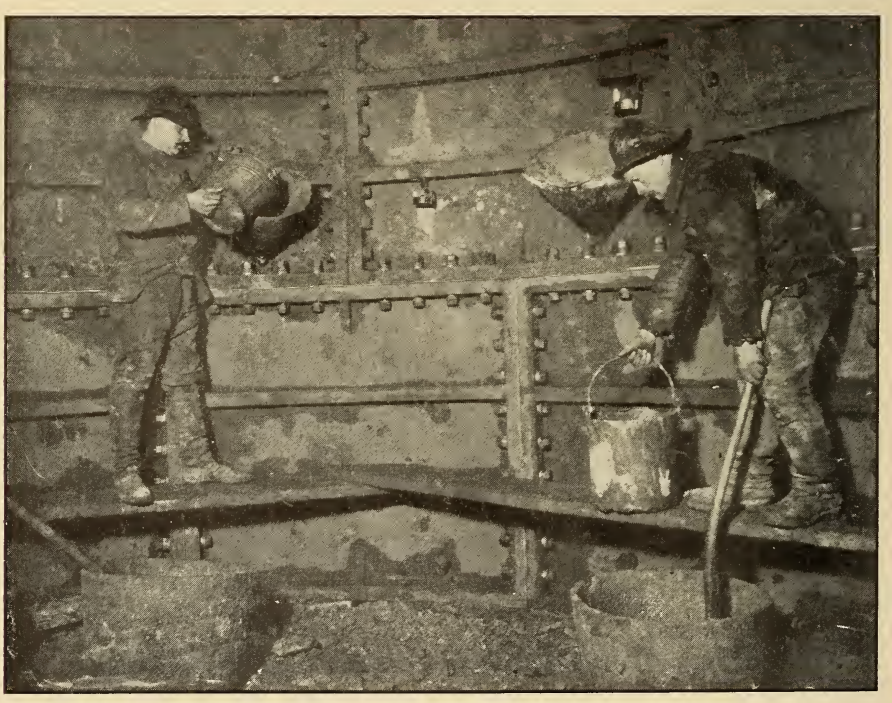
The vertical joints have already been tooled and are bolted together on a surface plate, for the horizontal flanges to be turned.

limit. It was finally decided to sink another shaft with a larger diameter.

Upon considering the pumping problem for the new shaft, it seemed desirable to employ units of much larger capacity. The hydrostatic head to be dealt with would, it was believed, never amount to more than 300 feet, or a water pressure of 130 pounds per square inch. Accordingly, three large pumps, each having a cylinder diameter of 24 inches, were installed. The capacity of these pumps was equal to the withdrawal of about 900 or 1,000 gallons per minute from a depth of about 350 feet with the steam pressure at 100 pounds per square inch. The steam and exhaust pipes had each a diameter of 5 inches, while the delivery pipe was 12 inches in diameter. The pumps and their equipment of steel piping were each carried by a pair of chains in essentially the same manner as already described. The method of raising and lowering the great weights was, however, quite different. Here wire-rope sheaves and a double-crab steam capstan were used. It was thought possible the four pumps might, perhaps, be needed, and provision was made for them.

The shaft was first sunk through the dry strata to a depth of 60 feet, when one of the large pumping units was started up. At a depth of 12 feet lower down the precaution was taken of installing a cast-iron crib. It was thought it might eventually be needed to hold down iron tubing in case that method of dealing with the water should be adopted. In the meantime, the method of sinking employed was the very usual one in which a wooden lining is kept in position by means of iron rings. This lining was removed and a brick wall substituted. This rested on oak curbs located at intervals of about 40 feet. At a depth of 192 feet a pebble-and-sandstone bed was reached, and the

inflow of water increased to about 900 gallons per minute. Two pumps took care of it. A back-casing curb was bedded in this vicinity. Shortly after reaching this depth a third pump was introduced into the shaft. Above the back-casing curb the brickwork was put in—but without mortar. Eighteen inches above the back-casing curb a garland curb was arranged, together with a suitable tank to catch the water from it. One of the pumps took care of this water. The sinking continued; suitable curbs were put in at intervals, and a cast-iron wedging crib was installed at a depth of 279 feet. Five rings of iron tubbing were put in and the space behind them filled in with cement. Another cast-iron wedging crib was arranged upon the sixth ring of tubbing. This was wedged and was protected and secured by cement at its back. The tubbing was carried on up to a crib-bed at 210 feet; another cast-iron wedging crib was here installed, and the tubbing continued on up to the crib put in soon after water was first encountered. As the inflow had not increased, the water tank was removed and "the pumps lowered into the pit bottom, two working alternately to their full capacity and delivering 1,000 gallons per minute." The tubbing was wedged and plugged. The water slowly rose back of the tubbing. Two valves had been arranged in the iron wall. These were closed and the pumping stopped. A small leakage was disclosed in the brickwork beneath the crib at the 279-foot level. This was dealt with by putting in another ring of tubbing, a small crib being arranged below. A cement backing was put in under a pressure of 200 pounds per square inch, which appears to have been double that of the water at this point. The shaft itself was carried down to a depth of 865 feet, when it reached a heading. Subsequently it was continued on down to a final depth of 1,662 feet. The water in the pebble beds went back to its former level



POURING CEMENT FILLING INTO THE SPACE BETWEEN THE TUBBING AND THE FACE OF THE SHAFT

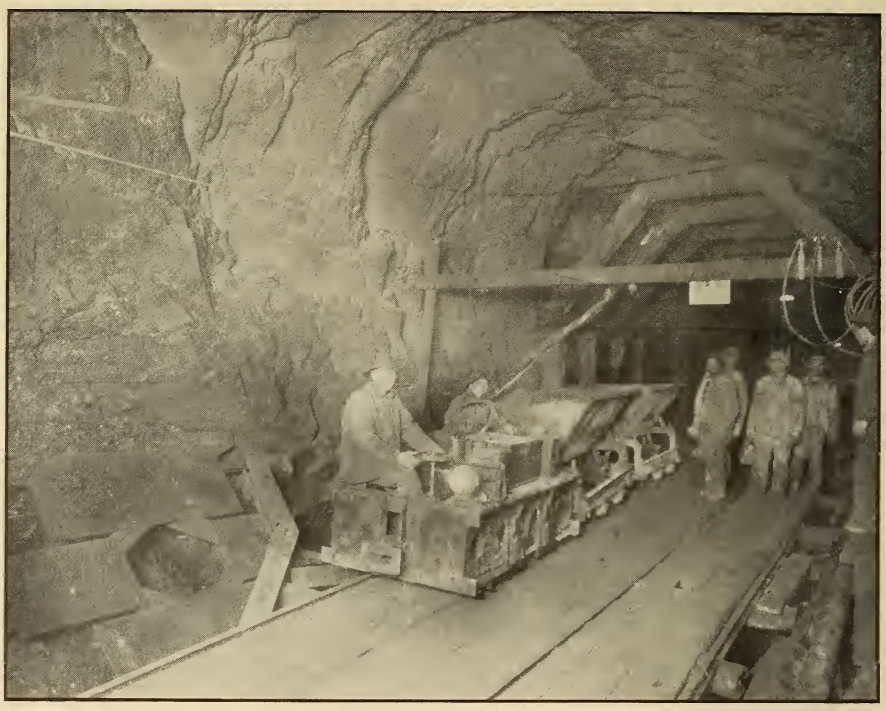
HOIST AND CAGES AT SHAFT ON RONDOUT SIPHON, CATSKILL AQUEDUCT WORKS

and overflowed the tubbing which fell short of the 69-foot level. A section of tubbing 44 feet in vertical length was afterwards installed, so that the iron casing now reached within about 36 feet of the surface. Altogether, its vertical length was 243 feet, reaching down to the 279-foot level. The total amount of water lifted from this shaft has been estimated at 366,840,000 gallons.

UNDERHANGING TUBBING

In this case of the No. 3 shaft at the Littleton collier·· the tubbing employed was supported from below and by skin friction. This method only permits a thoroughgoing sealing of the side walls after considerable intervals. In other words, there is a lack of continuity about it. The underhanging tubbing seeks to correct this, at times, serious imperfection. The tubbing is added to from below. It grows then precisely in the direction of the growth of the excavation itself. It is thus possible to keep the bottom levels of each within a very short distance of each other. As it is ordinarily possible to seal the space back of the tubbing with cement grout as the iron wall is put in, the water problem can be confined to the extreme bottom of the shaft.

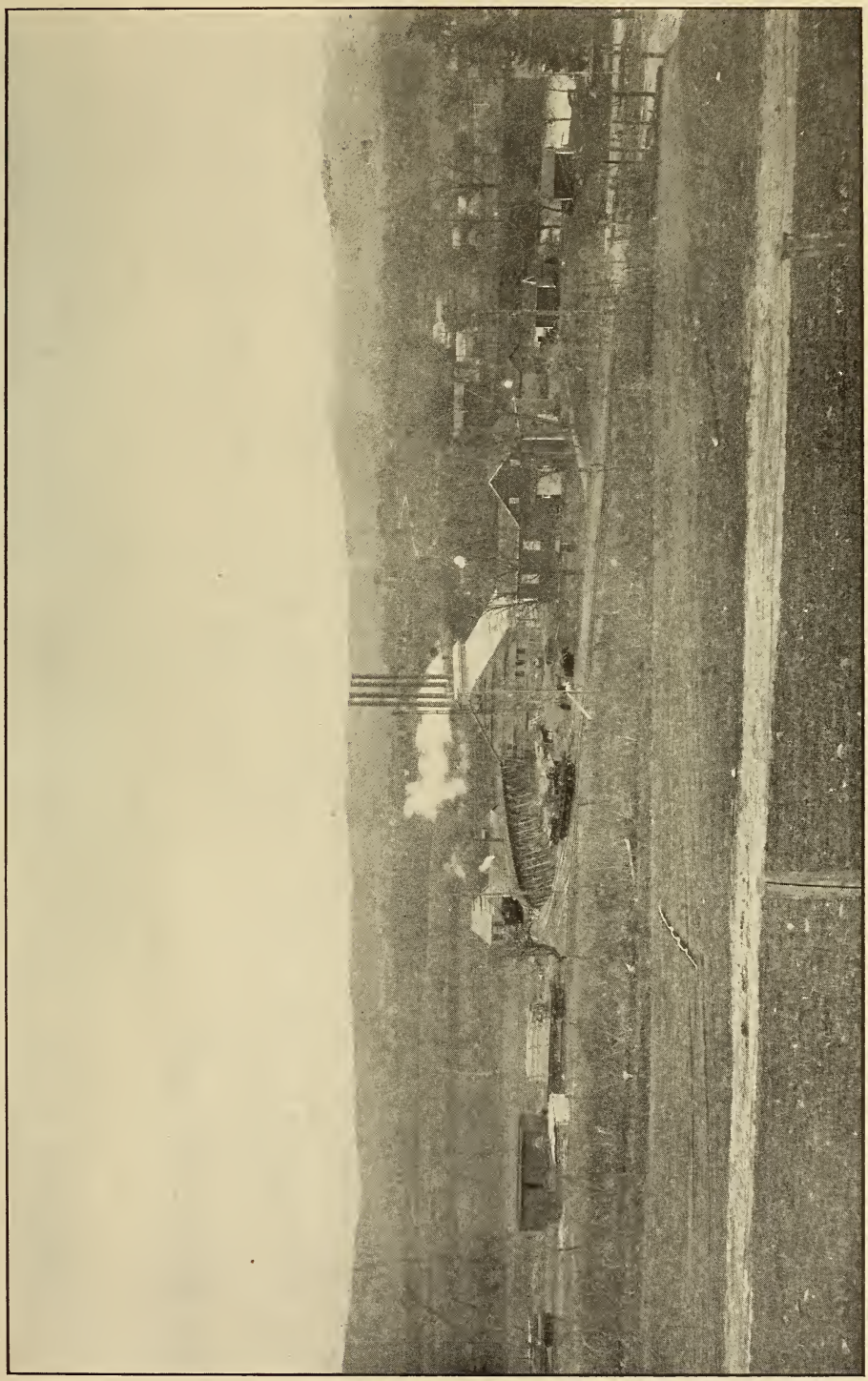
A shaft was recently put down in England in the sinking of which the system of underhanging tubbing was employed. The shaft was not a deep one, and the water problem was not a serious one; still, interest attaches to the work because of the method. This shaft is located at Hamsterley colliery, near Newcastle-upon-Tyne. Just after excavation began water was encountered. There were two strata: one 9.5 feet thick, consisting of sand, gravel and water. A curb must be put in to afford a point from which to hang the tubbing. This was of cast iron and provided a circular flange surrounding the hole of the shaft and affording a means of support for the tubbing ring, which was placed next. Both curb and rings were segmental. The segments were bolted together, making vertical joints.



ELECTRIC LOCOMOTIVE AND CARS FOR CONCRETE, WALKILL DIVISION, CATSKILL AQUEDUCT

Below, another segmental ring would be bolted onto a bottom flange of the first ring. There would thus arise a horizontal joint. All these joints were made watertight by machining the flange faces and by using lead sheeting in the joint. Grout holes were arranged at suitable points. When a ring was in place, with all seams filled with lead and the bolts tightened, the space back behind the metal was ready for grouting. The first thing to do was to provide a bottom to this space. This was accomplished by ramming in well-puddled clay. When no opposing pressure is to be encountered from the water, the grout may simply be poured in, using suitable funnels.

When a ring has thus been put in and a cement seal made, the excavation can go a little deeper. At this shaft a little difficulty was experienced in putting in one of the rings because of the falling in of the sand. Afterwards, short slabs of wood—2.5 feet in length—were used in the manner of piles. These slabs would be driven in below the ring in an oblique direction, and served to restrain the sand until the sections of one ring of tubbing could be gotten into place. Brushwood was also found useful for the same purpose, as Mr. J. Cummings informs us. The pumping required was inconsiderable. Two men working a hand-pump were able to deal with the conditions for a space. Then a small pump, having a capacity of only 150 gallons per minute, took care of the incoming water. A frame, 3 feet square and 1.5 feet deep, provided a sump at the bottom of the shaft. The sinking, together with putting in tubbing and grout, occupied twenty-eight working days. The wall of iron was 55 feet deep, and weighed about one ton per vertical foot. The diameter of the shaft was 10 feet, and the thickness of the cast-iron wall was 1 inch. There were hori-



CENTRAL POWER PLANT, RONDOUT SIPHON, CATSKILL AQUEDUCT WORKS

zontal reinforcing ribs in addition to the vertical and horizontal flanges. A larger pump, having a capacity of 500 gallons per minute, was employed as the shaft penetrated the stone below the soft strata where the tubbing was used. It would thus seem that the method of underhanging tubbing enabled the tubbing problem to be greatly simplified.

A DIFFICULT AMERICAN SHAFT

Between the northern boundary of New York City and the great Ashokan Reservoir, in the Catskill Mountains, the Castkill Aqueduct will measure about 90 miles in length. It is not everywhere the same. Sixty-nine miles of this length is to be constructed along the hydraulic grade. Consequently, provision does not have to be made for resistance to a head; and the conduit will be constructed in these portions either as a cut-and-cover tube or as a simple tunnel through the rock. These 69 miles are distributed here and there, and by no means constitute a single, continuous section. Elsewhere the aqueduct dips down below the hydraulic grade. This fact entails provision for resistance to the hydraulic pressures, due to various heights of head. Seven sections falling below grade will be constructed in solid rock. These portions are inverted siphons. They aggregate 17 miles, or 18.5 per cent. of the length of the aqueduct north of New York. Some of these siphons will have long horizontal sections connecting the vertical portions. The crossing of the Hudson River will be by inverted siphon. Here the depth below the surface of the river will be about 1,200 feet. As the hydraulic grade at this location is 400 feet above the river, it will be seen at once that there will be a pressure due to heads up to 1,600 feet. The first siphon south of the Ashokan Reservoir is at the point where the aqueduct crosses the valley of the Rondout Creek. The maximum depth here will be 710 feet. The bottom portion of the siphon will be nearly 4½ miles long. This portion will be at two levels, a short, inclined section connecting the two. Of these 4½ miles, the Rondout Creek occupies a negligible portion. It will be seen at once that the removal of the spoil due to excavation would be difficult if it had to be transported to either the down-take or up-take shaft. Consequently, in this type of construction a number of working shafts will often constitute a solution of the transportation problem. At the Rondout valley there are five such auxiliary temporary shafts, and a sixth shaft which will be a prominent one. One of these, known as Shaft No. 4, is located a little to the east of the N. Y. O & W. R. R. Its depth is 498 feet. For 80 feet the sinking was accompanied by no problems due to water. The remainder of the distance was through heavily watered strata.

This shaft is one of the temporary auxiliaries, and is rectangular in section, measuring 10 x 22 feet. The 2-inch planks used for lagging are held in position by heavy timbers. In this way the walls are preserved. The timbering reduces the effective size of the shaft to 8 x 20 feet.

Prior to the sinking of this shaft it had been ascertained that there would be trouble with water. An emergency pumping plant was ordered by the A. S. Cameron Steam Pump Works, foot of East Twenty-third street, New York. The five pumps ordered had a combined capacity of 2,100 gallons per minute. While waiting for these several Cameron sinking pumps were held in reserve. However, before delivery was made of the emergency plant and when the shaft was at about the 80-foot level, water entered through a large bore-hole and filled the shaft half full. An air-lift pump, together with two of the reserve pumps, already mentioned, succeeded in unwatering the shaft to a level near the bottom. The bore-hole was now plugged with cement and the unwater-

ing completed. For a time the excavation went on in dry limestone, but from a depth of 215 feet the water began to increase. At 260 feet the inflow was 225 gallons per minute. Two sinking pumps—apparently the two reserve pumps which assisted in the first unwatering—took care of this water. As the sinking went on the inflow varied, rising to nearly 900 gallons per minute. But as the excavation of the tunnel itself went on this influx increased to about 2,000 gallons per minute. As we are informed by a paper of Mr. Flinn's, the flow of water at this shaft was maintained at 1,300 gallons or more per minute for many months. The number of pumps needed to handle the water became so large as to necessitate a special pump chamber on one side. A room 17 x 24 x 10 feet was accordingly excavated at the 309-foot level. This chamber was provided with a 14,500-gallon sump. Three Cameron pumps of the horizontal type, having an aggregate capacity of 1,050 gallons per minute, were installed here. A second chamber was arranged at the bottom of the shaft. The great difficulties encountered in sinking the shaft, of which the water problem was only one, prolonged the work so much that the average progress was only about one vertical foot per day. It is thought that the pumping chamber should have been provided at an earlier stage of the work, and not have been deferred—as it was deferred—until the excavation had gone more than 300 feet. The large pumps in this chamber were run by steam. The engines belonging to them were of the condensing type. The steam supply pipe—4 inches in diameter—was covered with asbestos, felt and tin, to prevent condensation of steam and fog.

The inflow of water was a great problem, but it was by no means the only one. A great deal of hydrogen sulphide was discharged into the shaft during the sinking operations. This produced physical difficulties for the workmen. In fact, upon one or more occasions it was found necessary to increase the wages and reduce the working period. Eventually, however, the shaft was completed with the use of wooden lagging. Much assistance was derived from applying a method of grouting ahead of the excavation. The following lesson would appear to be derivable from the experience with this shaft: Where large quantities of water under a hydrostatic head exceeding 200 feet have to be dealt with for long and uninterrupted periods, the multiplication of sinking pumps and the consequent crowding of the shaft can be avoided by installing adequate plants of horizontal pumps in special chambers arranged in the wall of the shaft.

MECHANICAL APPLIANCES FOR DUST EXTRACTION IN COTTON MILLS

By H. M. Crawford

IN a previous article on dust extraction* we dealt in detail with apparatus in which the motive power was applied to *exhaust fans* in immediate connection with flues and ducts leading from individual carding engines.

It is the purport of this essay to deal with *vacuum* systems of extraction now in vogue in Lancashire cotton mills. The method of extracting dust by means of a partial vacuum is not in itself a very recent invention. Its application to the cleaning of rooms, carpets and tapestry is well known, but its employment for the purpose of dust extraction during the process of card-stripping is a recent adaptation of great significance. Dust from the card cylinder may now be given its quietus, so far as its baneful effect on the employees is concerned, and there is no lack of efficient devices for removing all dust evolved during stripping operations, either by fan-power or steam pressure. The dust itself varies in density, but is generally divisible into:

1. Light, short fibre, coated more or less with a fine black powder;

2. Heavier material, Fig. 1, containing husk, sand, flint, seeds of weedy plants, and specks of metal.

The husky material is cellular, and forms part of the original cotton plant. The siliceous matter is a more serious item, and appears to be largely responsible for the injury done to the health of the strippers and grinders. The particles are angular, sometimes sharply pointed, and, as such, are likely to disturb the delicate membranes of respiratory organs. It is certain that no workman can inhale such an agglomeration of vegetable and mineral dust with impunity for any great length of time.

The services of the engineer, therefore, in clearing the atmosphere of the mill are most opportune; and if proof were required as to the great boon conferred by these services it is to be found daily in the improved health of the workmen where extracting appliances have been installed.

In the "Vacuum" system (Hargreave's patent) the appliance is actuated by a vacuum pump of two or three cylinders, Fig. 2, according to the number of carding engines to be stripped simultaneously. The pump may be driven by belting from an overhead countershaft, such as obtains in every card room, or by means of a rope and grooved pulleys. Or, if it is desirable to drive it independently, a small electric motor may be installed and used at stripping periods only. The absorption of power averages about 4.5 horse-power with a three-cylinder pump and 3.5 horse-power in the case of two cylinders.

The lower cavity of the pump is occupied by a dust collector, made in the form of a strong canvas bag, which allows the air to percolate freely without permitting the passage of dust or fibre. It follows, therefore, that all refuse material which is thrown off from the card cylinder in the stripping process is ultimately deposited in this collecting bag. It is attached to a flange, Fig. 3, on the inner side of the cavity door, to which, on the outer surface, the

* See Cassier's Magazine, November, 1911.

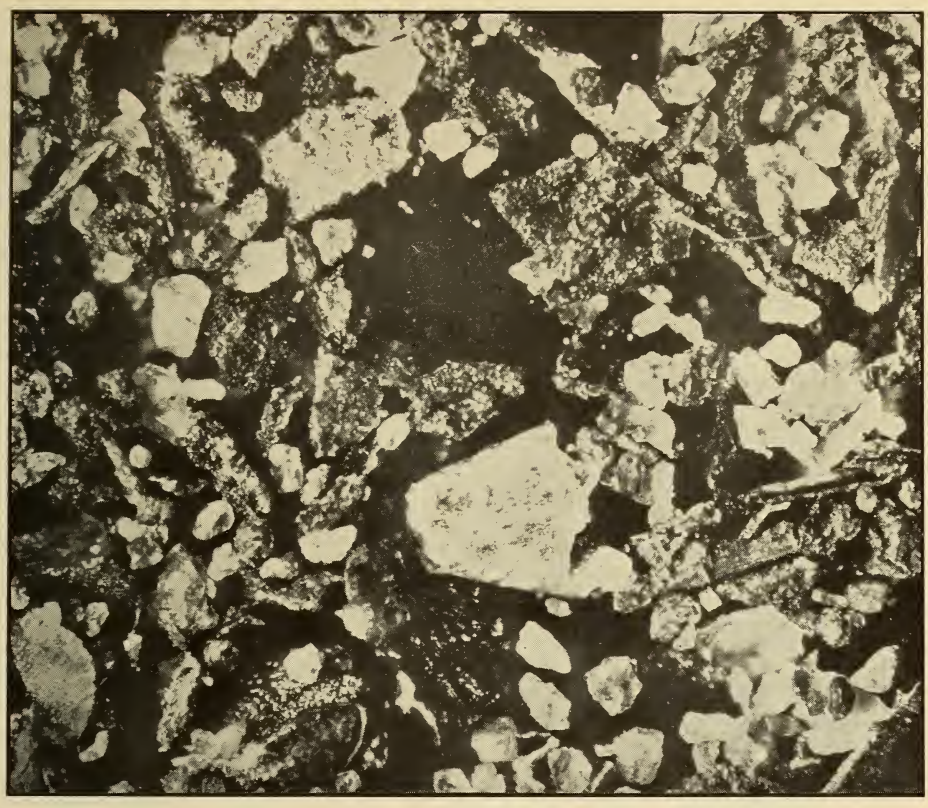


FIG. 1.—STRIPPING-DUST TAKEN FROM THE HEAVIER TYPE FROM CARDING ENGINE. MAGNIFIED 30 DIAMETERS

flexible dust-carrying tube is fixed. The bag is easily disconnected from its holding bands, and then discloses its contents. A fair estimate of the nature of these may be obtained by reference to Fig. 4, in which the basket *A* contains the contents of the dust-bag. Such a collection of dust, dirt, fibre, sand and infinitesimal sticks is here present that one wonders why this useless stuff was not long ago separated from good cotton. The contents of the basket *B* are what is known commercially as "waste," being the longer fibred cotton left on the stripping-brush after the dust has been extracted. This "waste" is useful for manufacturing purposes, and is treated again by the machinery of the factory. The refuse of the dust-bag, however, can have no claim to further treatment in a cotton mill; it is conveyed to the fields for use in agriculture.

The accumulations of the dust-bag vary in bulk with the quality of cotton used. With coarse American cotton it may be advisable to empty it four times weekly. In the case of fine Egyptian, where the carding is light and the stripping of the cylinder less frequent, it may not be necessary to empty the bag more than once a week. It is clearly a wise practice not to allow the collector to be overloaded.

The air displacement works out at about 100 cubic feet per minute, so that there is a substantial interchange from dusty to clear air while the card stripping is in progress; and if the pump is erected in a room separate from the card room, there is a further beneficial interchange, directly due to the drawing in of ordinary outside air at a gently accommodated temperature.

The vacuum created by the pump

is registered on a Bourdon vacuum gauge, and varies during stripping operations from 16 to 25 inches. At the beginning of the work the suction is allowed to reach 25 inches. This gives ample margin for efficient cleansing of the card cylinder from the very first contact of the stripping-brush. Some notion of the suction power of this vacuum may be gleaned from Fig. 5, in which the valve on an up-take pipe over a carding engine is shown fully opened and a double spanner holding a book is kept in firm contact without any support. A coin applied to the orifice of the tube would rapidly disappear; a handkerchief was sucked up with equal avidity. There can, therefore, be no question that the

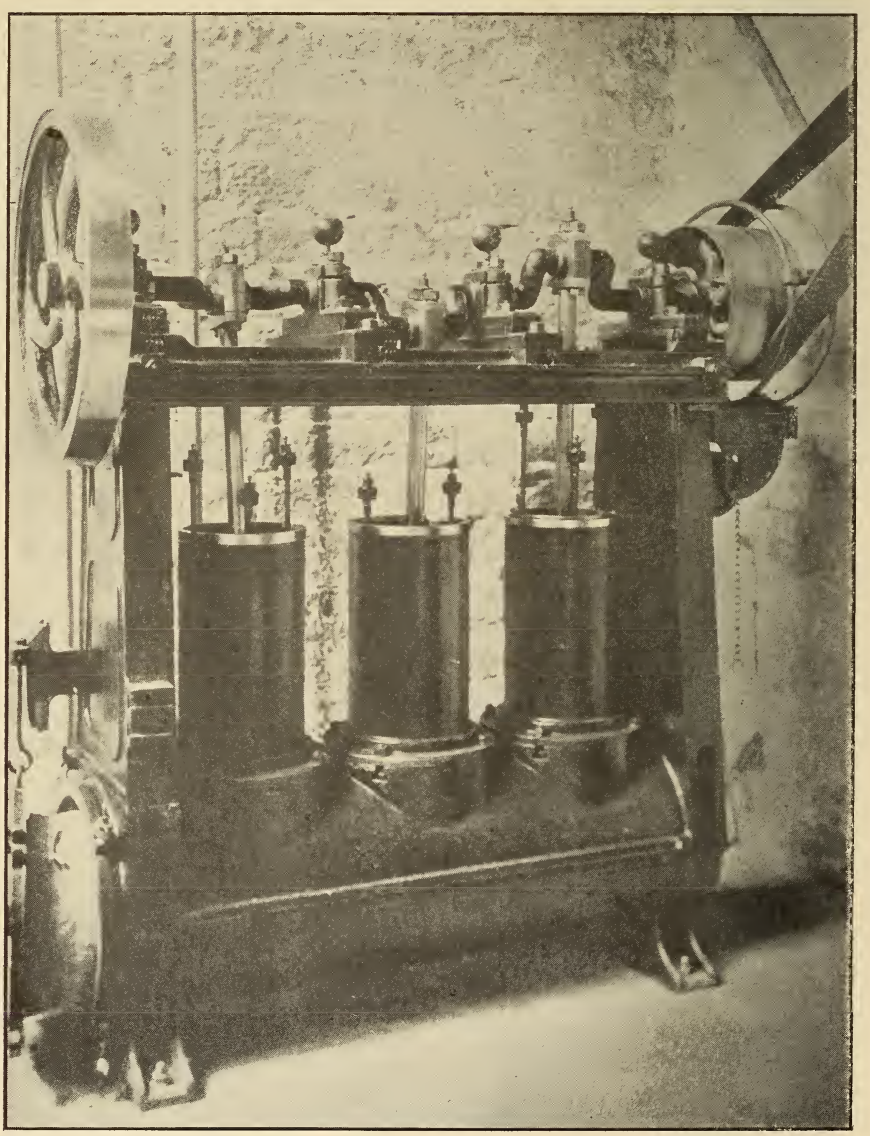


FIG. 2.—HARGREAVE THREE-CYLINDER SUCTION PUMP

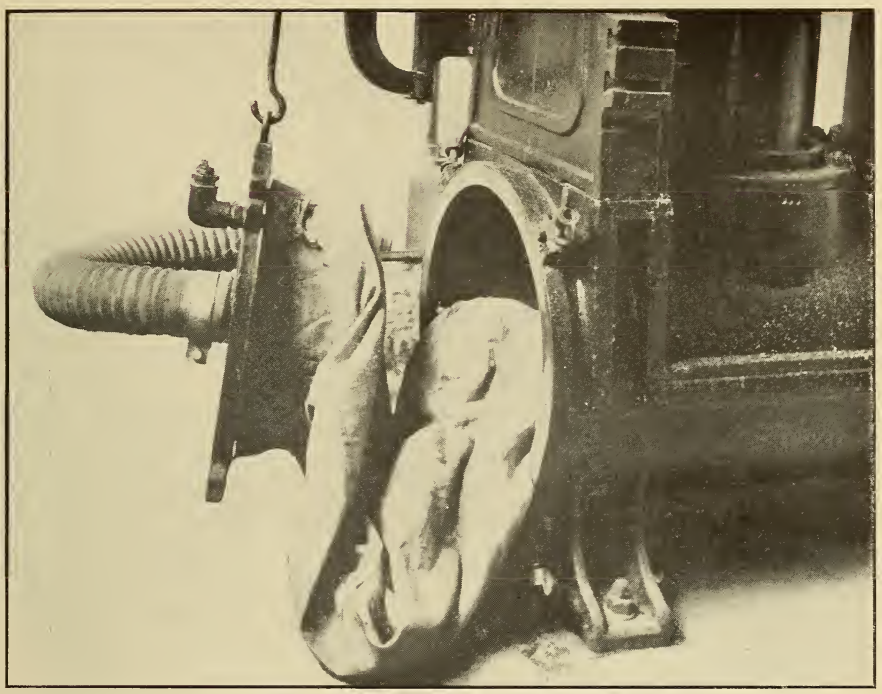


FIG. 3.—DUST BAG IN LOWER CAVITY OF SUCTION PUMP SHOWN IN FIG. 2

FIG. 4.—STRIPPING-DUST IN *A*, AND VALUABLE "STRIP" IN *B*

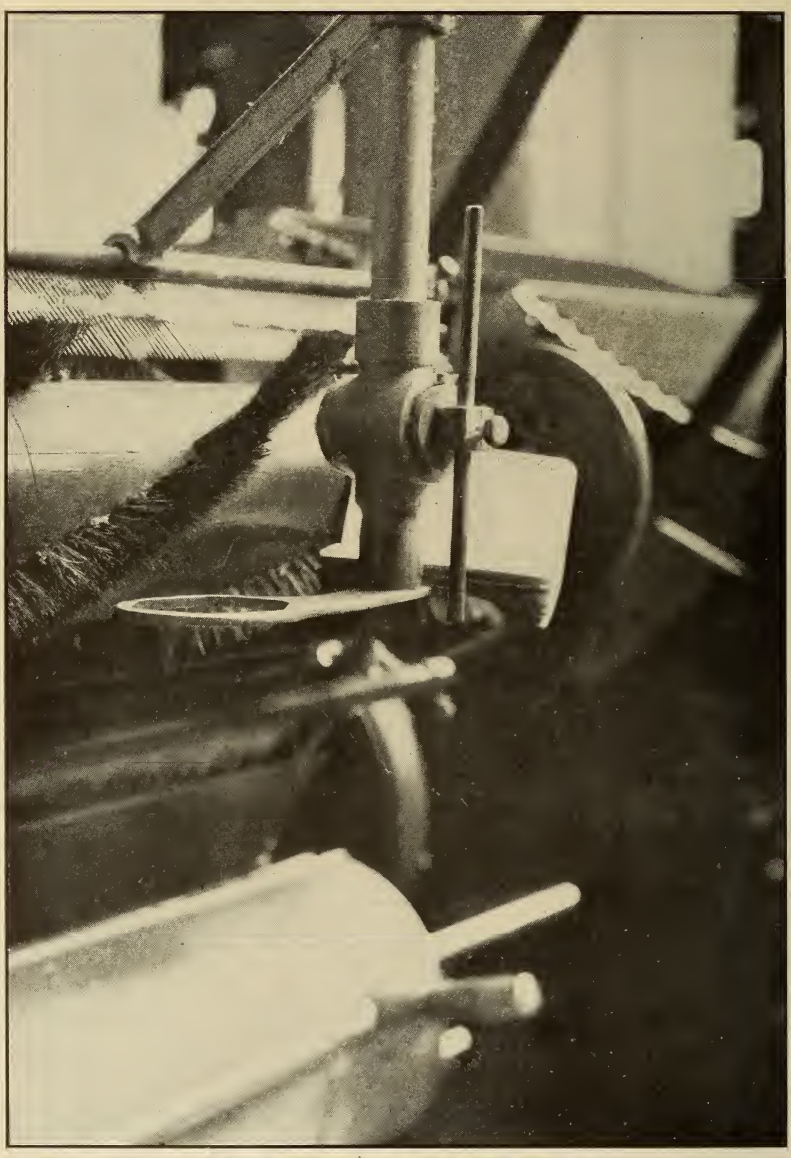


FIG. 5.—SPANNER HELD UP BY FORCE OF SUCTION

vacuum created is sufficient to absorb the dusty components generated by the stripping-brush.

We may now view the appliance as fitted to the carding engine, Fig. 6. Here the up-take tube, one inch in diameter, is seen at *A*, held in vertical position by a stay resting on the comb bar of the machine. The valve is open, as indicated by the tap handle, and the end of the up-take is accommodated with a flexible tube fixed near the centre of a hood which covers the stripping-brush. It will be understood that all parts of this brush are embraced in the hood, except where the former is in contact with the carding cylinder. Hence, when the brush is set in motion by means of the grooved pulley at the

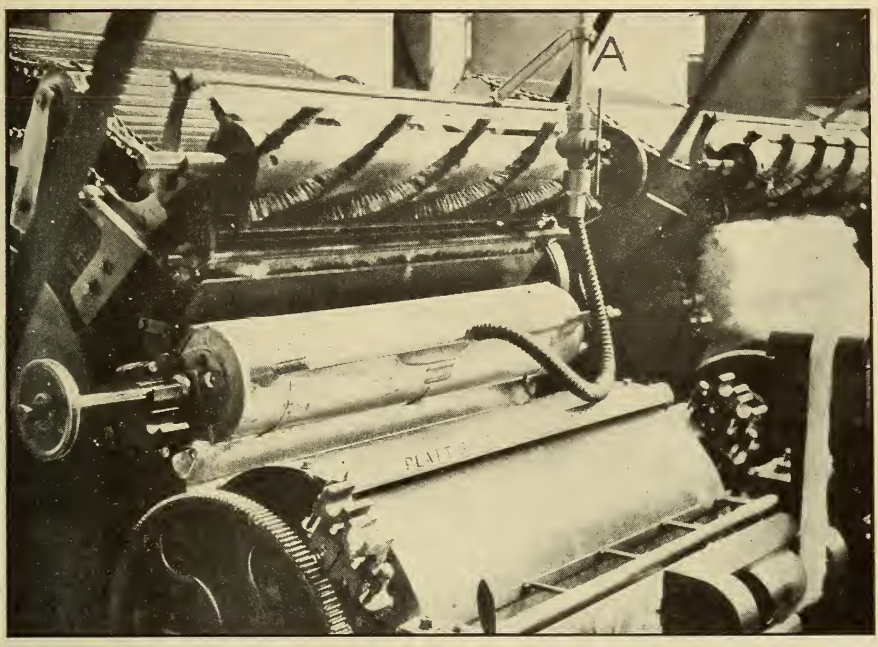


FIG.. 6.—VACUUM EXTRACTOR ON MAIN CYLINDER OF CARDING MACHINE

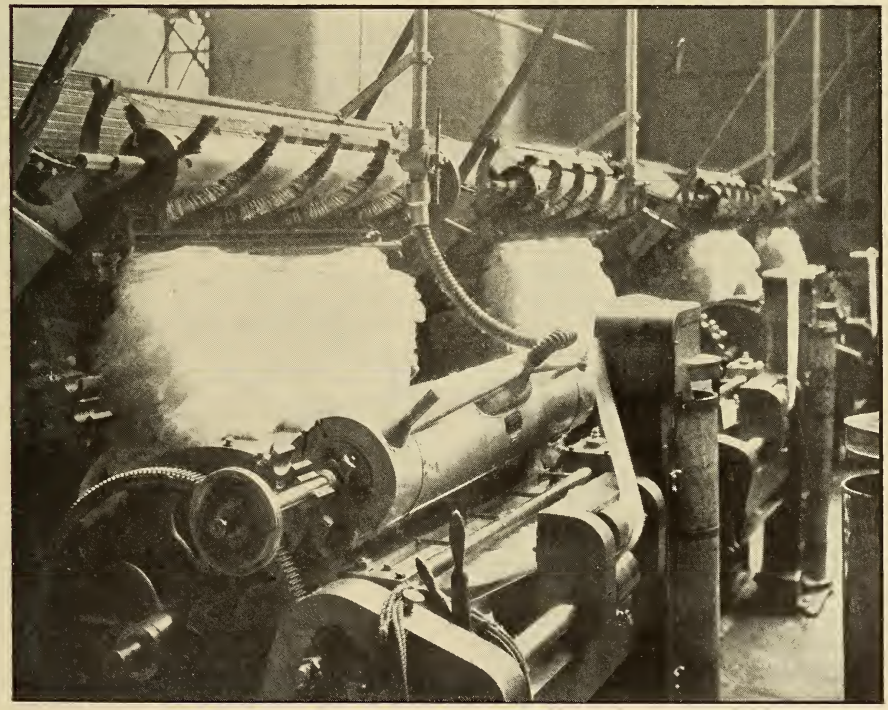


FIG. 7.—VACUUM EXTRACTOR ON DOFFER—WITH UP-TAKE PIPES OVER A SERIES OF CARDING ENGINES

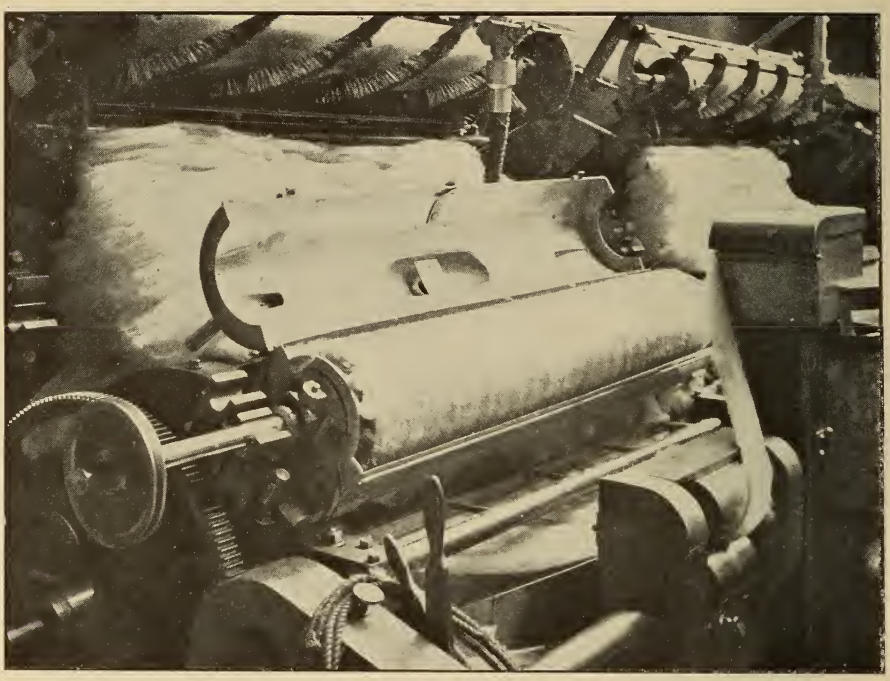


FIG. 8.—STRIPPING-BRUSH HOOD OPENED

end of the brush shaft any dust which is evolved is caught up under the covering hood, sucked by the vacuum pump into the up-take tube and ultimately into the collecting bag.

The hood itself is constructed of light sheet metal with aluminium ends and bushes, so as to reduce the aggregate weight within reasonable working limits. The hood on a 37-inch card weighs about 10 to 12 pounds. The "horns" of the hood are provided to enable the strippers to manipulate the apparatus with greater facility. In Fig. 7 the up-take pipes are seen over a series of carding engines. These being coated with aluminium paint, make no obstruction to the lighting of the room. It will appear, further, that after stripping the main cylinder of the machine it is merely necessary to lift the brush and cover bodily to the doffer cylinder; then by application of the driving band to the grooved pulley this cylinder is stripped of its dust in exactly the same way as the main cylinder. Then the hood is opened, Fig. 8, the upper half being hinged for the purpose, and the clean cotton, or "strip," as it is termed, is abstracted from the stripping-brush by means of a T-shaped hand-card. This completes the operation on one machine; and no dust has been allowed to vitiate the atmosphere of the room, or to be deposited on the manufactured material. This latter advantage will be more widely appreciated as the adoption of dust extractors becomes more general.

The fine-spinning mills of Bolton and suburban districts have welcomed the advent of dust collectors, inasmuch as these have materially promoted the quality of the yarn. Dust and dirt in fine-counts twist or weft do not promote sales on the Manchester Exchange.

The "Atlas" system of dust extraction embraces special points of its own. Its actuating force is drawn from the steam boiler in use at the factory. From this constant source

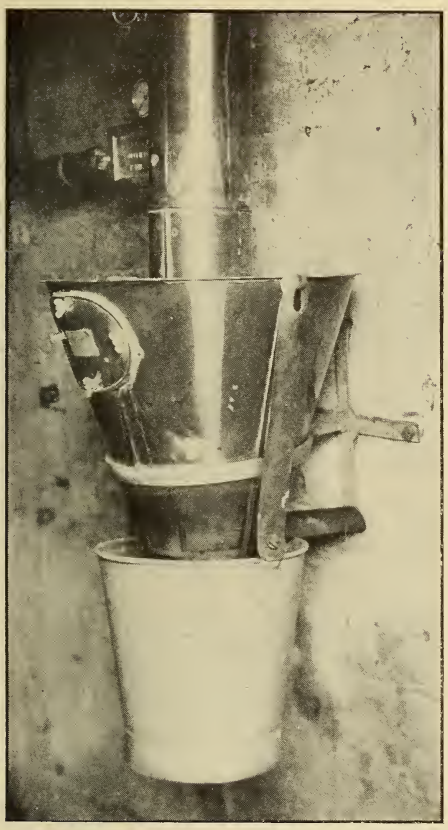


FIG. 9.—ATLAS DUST RECEIVER

steam is injected into a small chest, where it meets the orifice of the dust tube in connection with the carding engines. A partial vacuum is created, and maintained so long as the steam passage continues. This can be easily regulated as to pressure by turning a hand-wheel in close proximity to the pressure gauge. The result is that suction power is varied, according to the number of carding engines treated simultaneously. The steam pressure does more: it forces the dust extracted through the tubes into a funnel-shaped receiver made of copper, Fig. 9, from which it is deposited, as a fine sludge, into a bucket or other open vessel.

Where a large number of carding engines—say 100 to 180—are to be treated, and three or four stripped at the same time, the steam chests may be fitted in duplex form, so as to accelerate the suction power in any required rates from one to two. The air displacement obtainable amounts to about 250 cubic feet per minute. The test of efficiency of the air current created by suction lies not so much with the carding engines near to the chests as to those 150 to 200 feet away. When thoroughly satisfactory, the terminal engines in any series of machines should be as free from escaping dust as those nearer the injector; and the arrangement under consideration en-

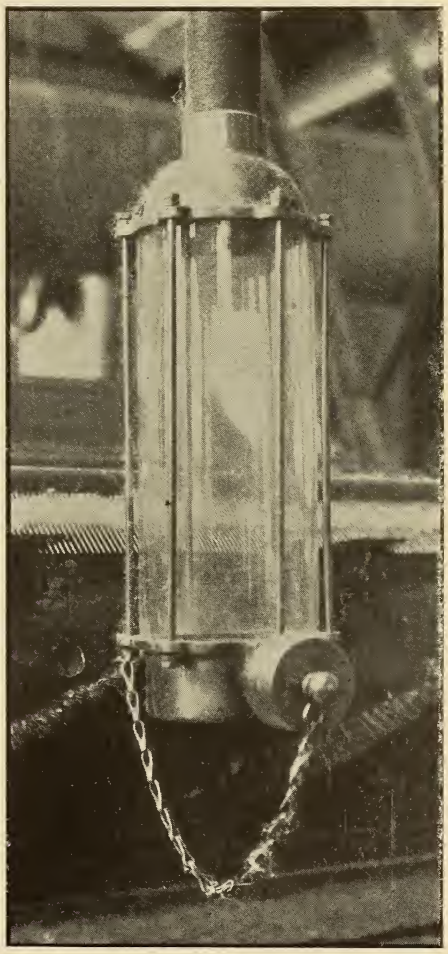


FIG. 10.—GLASS OBSERVATION CHAMBER ON UP-TAKE PIPE

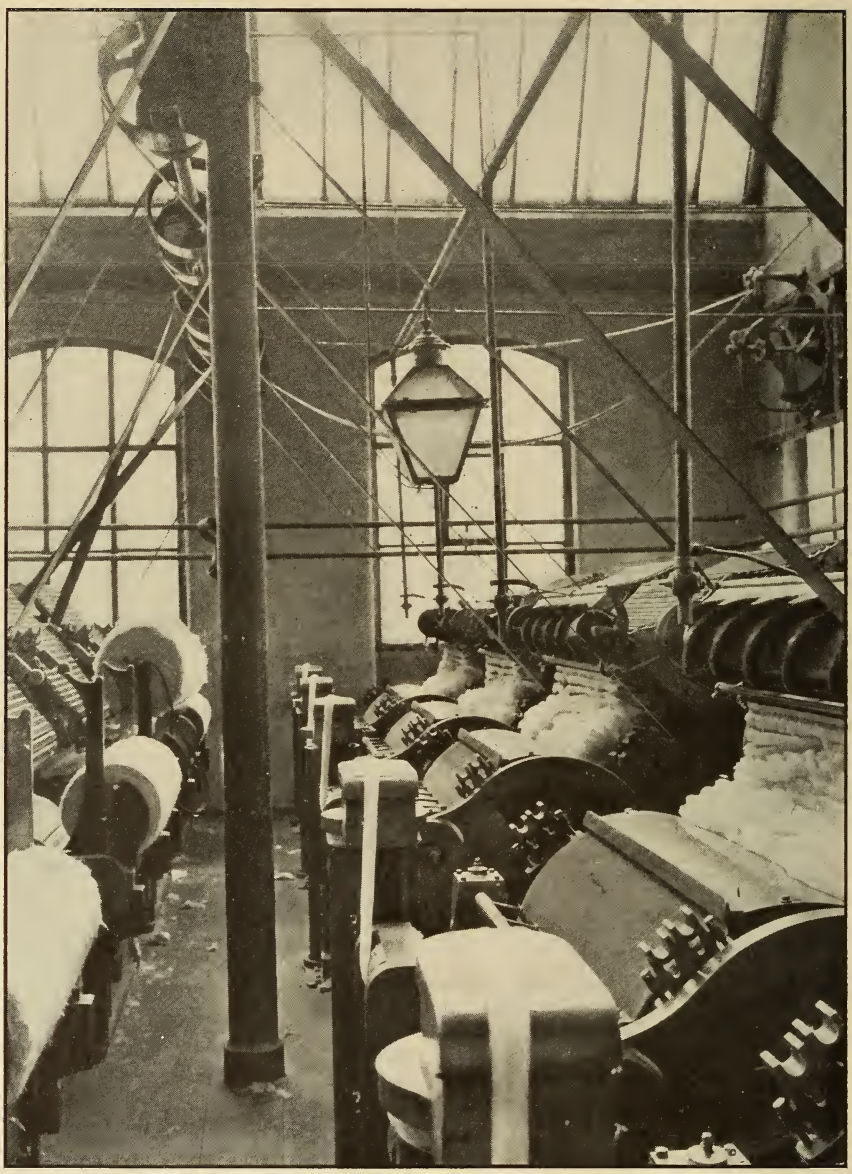


FIG. 11.—ARRANGEMENT OF UP-TAKE PIPES OVER EACH CARDING ENGINE

deavours to meet that contingency. The vacuum registered on the gauge during stripping operations ranges from 12 to 15 inches.

In connection with the steam chest 2-inch pipes are laid horizontally over each line of carding engines; from these 1-inch vertical pipes depend over each machine, Fig. 11 terminating in a valve operated at the will of the stripper. The stripping-brush, Fig. 12, is encased in sheet metal, which omits only the part in close contact with the card cylinder; the ends of the casing are filled in with aluminium, and the lid allows of ready access with a hand-card for the purpose of removing the "strip."

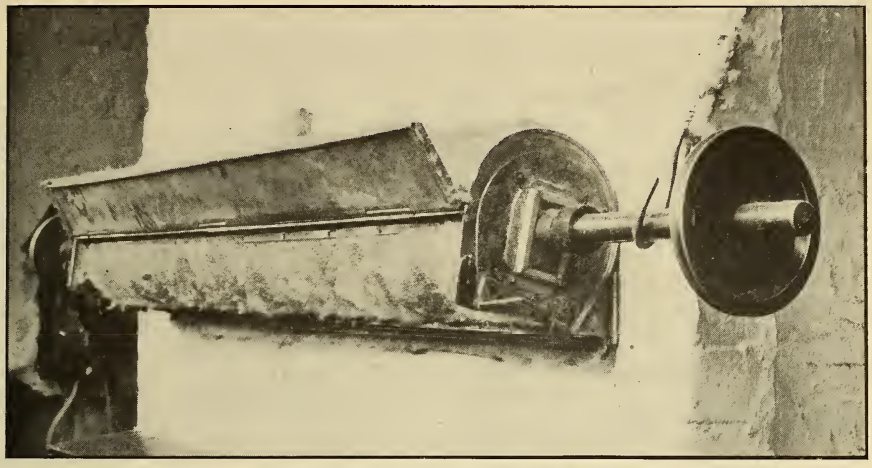


FIG. 12.—COVER-LID OF ATLAS SYSTEM RAISED

It is obvious that the addition of a casing to the stripping-brush will increase the weight to be carried by the strippers from one machine to another, and efforts are in progress among ventilating engineers generally to reduce the added weight to as low a minimum as is consistent with practicable working.

The application of the stripping-brush in the "Atlas" system is shown in Fig. 13, where the main cylinder is dealt with. A flexible tube connects the vertical tube with the casing, the

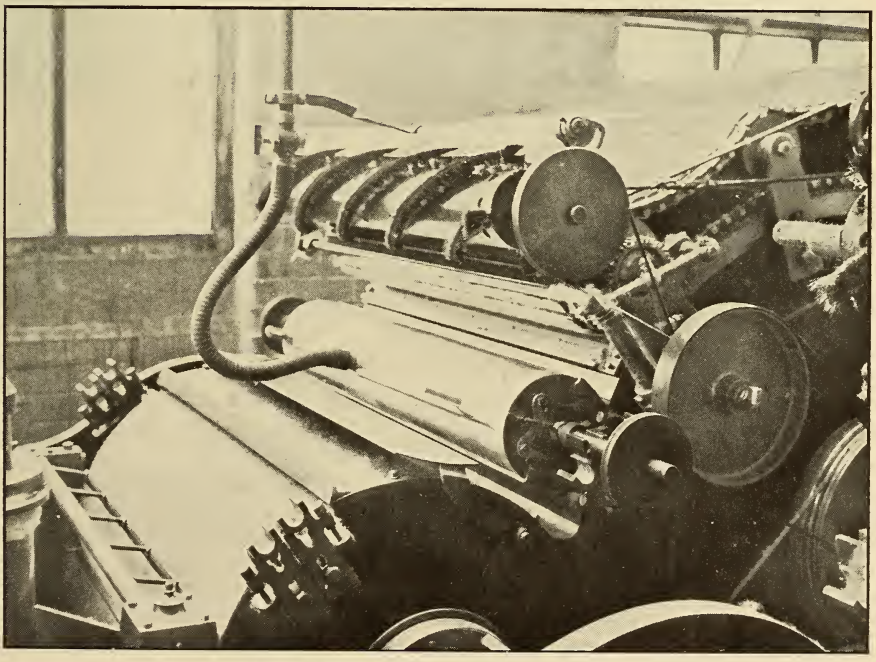


FIG. 13.—THE ATLAS EXTRACTOR ON A MAIN CYLINDER

valve tap is opened, the band is applied to the grooved pulley on the brush shaft, and dust extraction then keeps pace with the stripping. The cylinder door is then closed, the appliance is transferred to the doffer, Fig. 14, and the process is repeated.

The cost of steam used expressly for the work of stripping cards is merely nominal. The operation is performed three to five times per day for fine or coarse counts, respectively, and, as a rule, not more than three carding engines are under brushes at the same time. An ingenious device, Fig. 10, in the form of a glass observation chamber has been constructed, so that the practical working of the appliance may be clearly seen during the cleansing of the card cylinder. The chained cap is detached and the flexible tube fixed in its place. As soon as the extracting appliance is set in motion the rapid currents of dust and short fibre are plainly visible.

In Cook's patent stripper provision is made for stripping and dust extracting in one operation. A vacuum pump, vertical, horizontal or three-cylinder, is at the head of the apparatus, and this, when set in motion, sucks the "strip" and dust from the carding engines into a spacious cylinder constructed of strong riveted plates and fixed to the ceiling. The outlet of this cylindrical receiver, Fig. 15, is about seven feet from the floor and well within reach of the operator. Internally, the receiver is lined with stout canvas, impeding the passage of dust or fibre into the working parts of the pump and retaining all material given off from the carding engine in the stripping process.

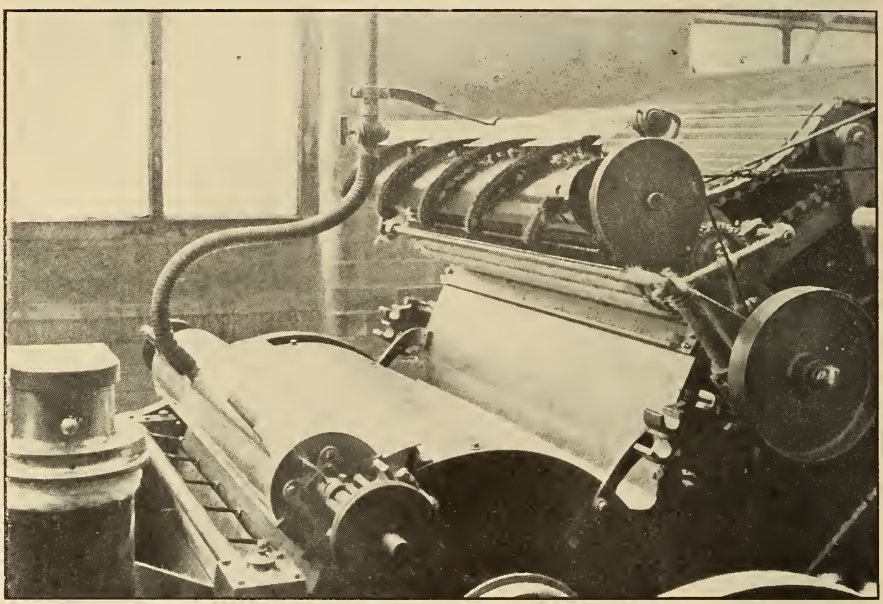


FIG. 14.—THE ATLAS EXTRACTOR ON DOFFER

The system is illustrated in Fig. 16, which shows stripping of the main cylinder in progress. It will be clear that in this arrangement the work is done at the back of the machine, and not, as is generally the case, from the front. Furthermore, the stripping is done by suction alone, no stripping-brush being used. When the suction pump is set in motion the operator merely attaches his flexible tube to the orifice of a

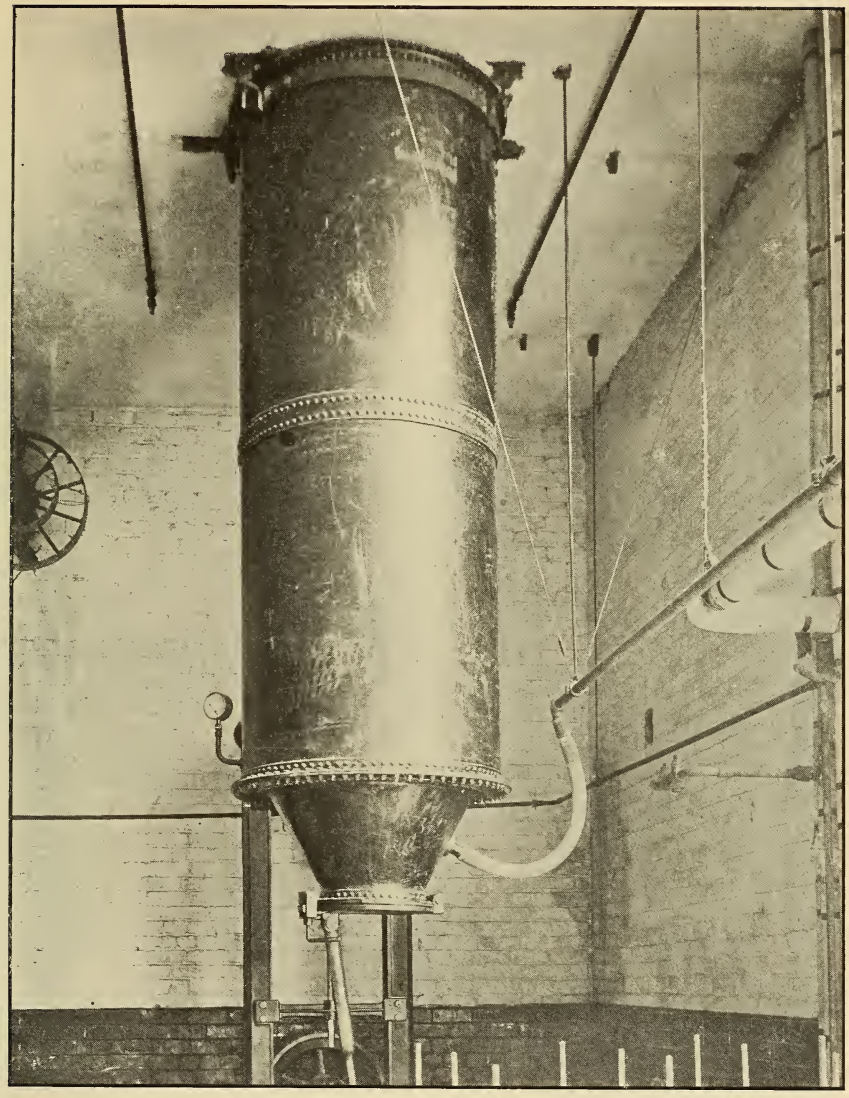


FIG. 15.—DUST RECEIVER IN COOK SYSTEM

nozzle and the current begins to act. The attachment of the nozzle is of great influence in the effective working of the apparatus. Two brackets are fixed to the frame of the carding engine, Fig. 17. These hold in position a traversing screw enclosed in a steel casing, which is slotted on its inner side. To this slot and screw a sliding bracket is fitted, which moves from side to side of the machine. The bracket, as seen in the illustration, carries the nozzle, through which "strip" is drawn by the suction current. The inner opening of the nozzle is flattened somewhat to cover one to one and one-half inches in breadth of the cylinder, and is located, at the will of the operator, so as to have the orifice one-sixteenth to one-eighth of an inch from the card-wire face. The back plate of

the machine is provided with a slot sufficiently wide to admit the nozzle, and yet close enough to debar the admission of operatives' fingers. Besides, a rising-and-falling flap is loosely screwed to the back plate, and this closes the slot mentioned as far as is practicable. As it is absolutely essential to prevent collision of the nozzle with the delicate points of the card-wire, the bracket and nozzle are fitted with mechanical precision. When the nozzle reaches the end of one traverse it remains stationary, but may be started on another journey by operating a clutch handle, Fig. 18. If, therefore, from the heavy nature of carding in coarse counts, it is necessary to pass the nozzle again over the wires, all that is required is to reverse the clutch.

The driving of the traversing screw is taken from a slow-moving pulley, which also operates the cleaning

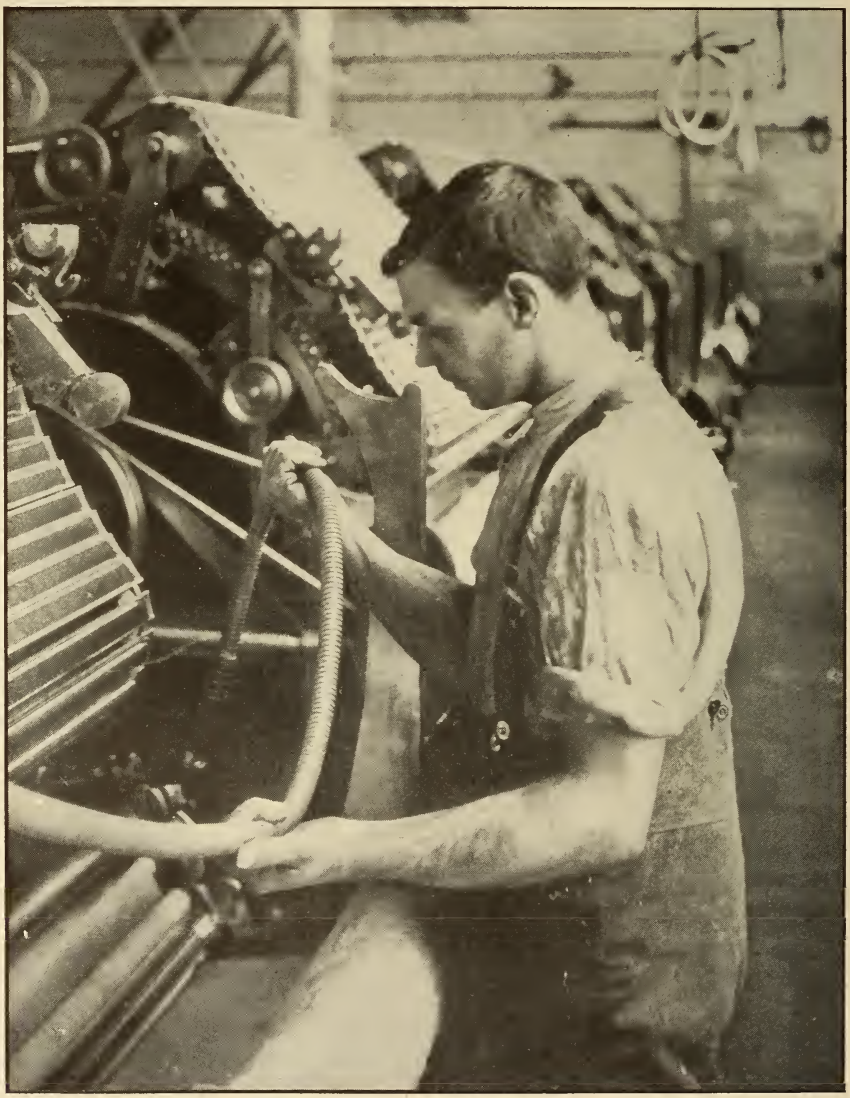


FIG. 16.—STRIPPING APPLIANCE WORKING ON MAIN CYLINDER, COOK SYSTEM

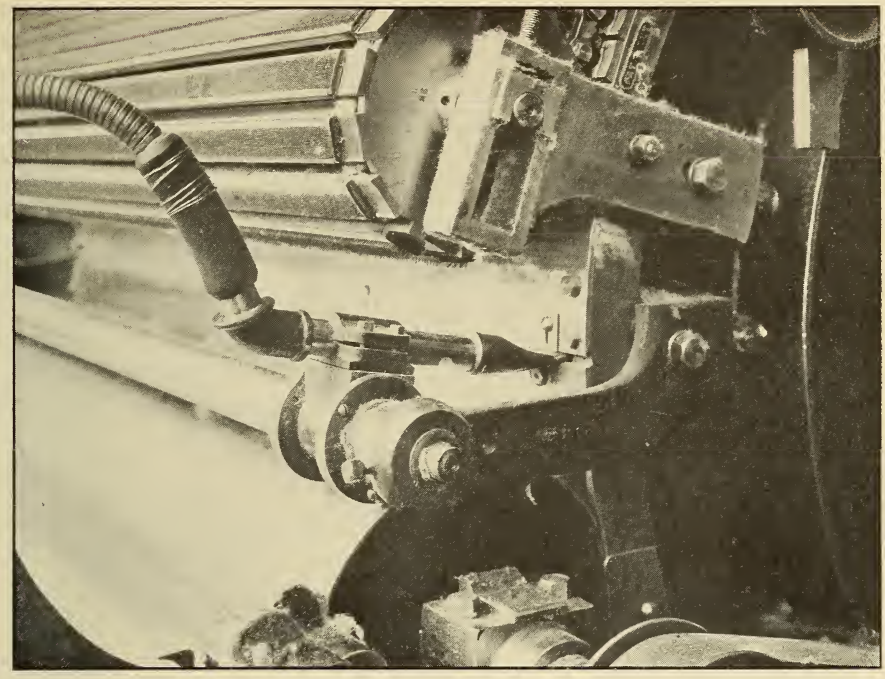


FIG. 17.—NOZZLE AND FIXING BRACKET

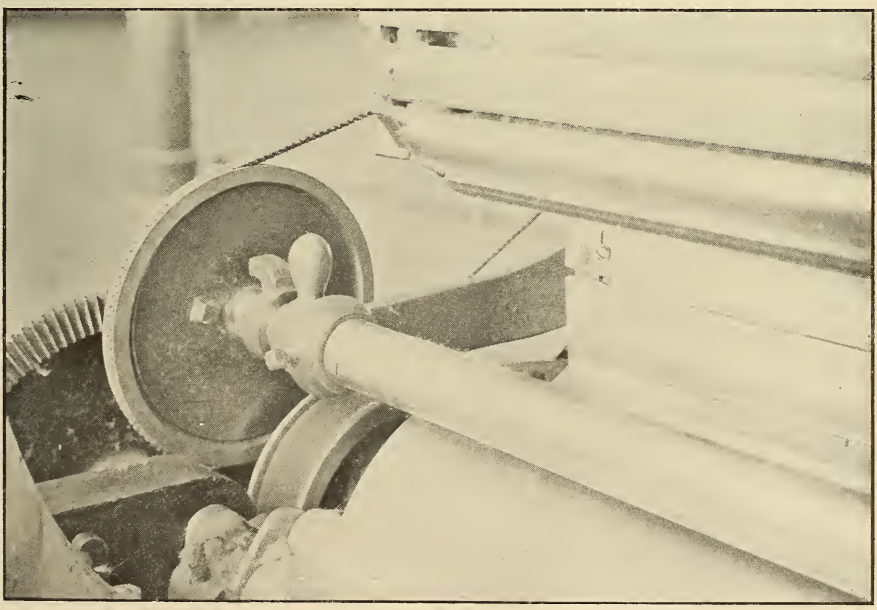


FIG. 18.—REVERSING CLUTCH AND TRAVERSING-SCREW PULLEY

brush for the card flats. The control and uniform movement of the nozzle are thus ensured.

The doffer cylinder is stripped, Fig. 19, on somewhat similar lines. The slotted tube with its traversing screw is fitted to the brush-brackets on each side of the doffer. The tube may be permanently fixed, as in the case of the main cylinder, or it may be held in the brush brackets

affect the webbing of cotton. This webbing is detached from the doffer before its surface reaches the suction line of the nozzle.

From the horizontal pipes, which follow the lines of carding engines, vertical pipes depend, one sufficing for three or four cards. The flexible tubes, Fig. 20, are long enough to reach these without strain, and, when not in use, the tubes are ranged on

FIG. 19.—STRIPPING THE DOFFER

with a guide screw resting on the doffer plate to keep the nozzle at a convenient interval from the card wire. Obviously, there will be relatively less effective suction on the doffer wires than on those of the main cylinder, owing to a portion of the doffer surface being entirely exposed. This point is surmounted by repeating the traverse of the nozzle where necessary. The "strip" from the doffer is never so plentiful as that from the main cylinder, and the application of the nozzle does not

hangers, with the tube orifices fixed on a solid plug. By this simple device wastage of suction power from inoperative tubes is obviated.

The amount of vacuum created must necessarily vary with local conditions as to power applied and work to be accomplished. In an average mill of, say, 80,000 spindles, with carding engines distributed on modern lines and with three nozzles acting simultaneously, the vacua will approximate to fifty centimetres when stripping three main cylinders, forty-

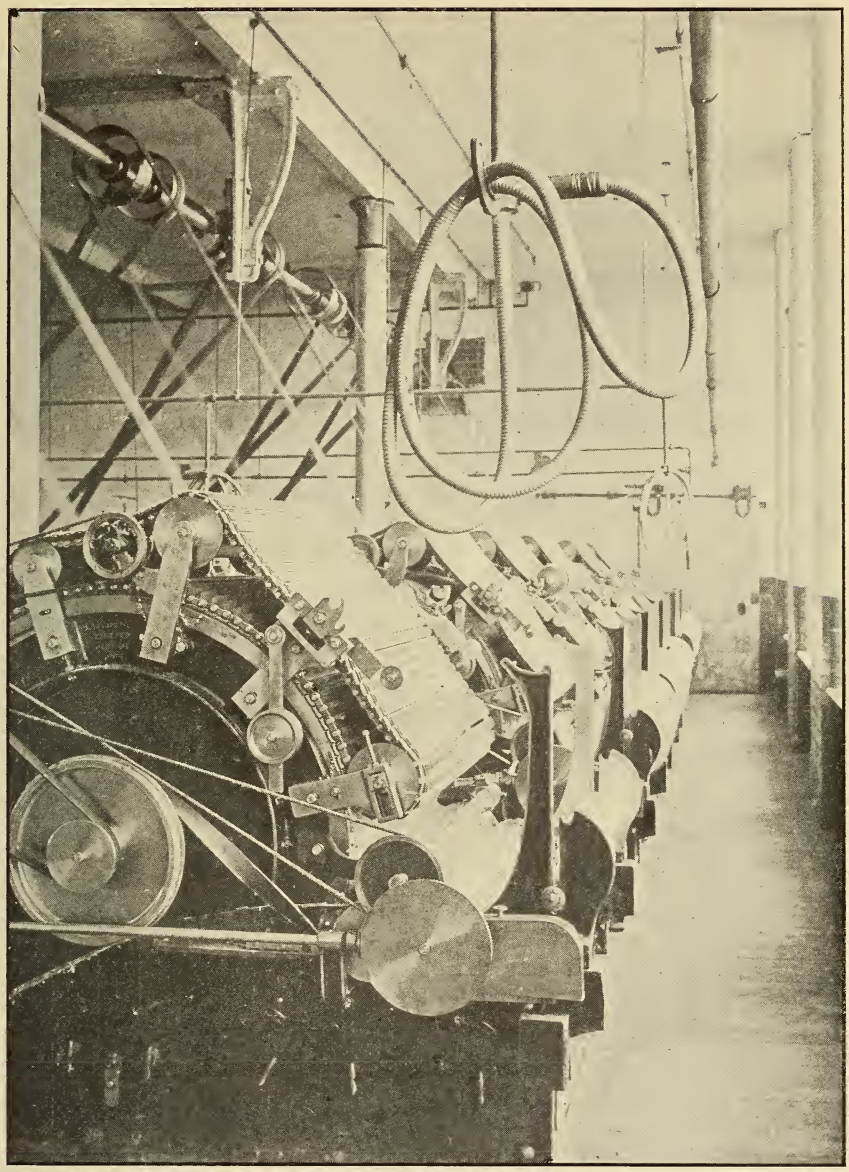


FIG. 20.—FLEXIBLE TUBES ON HANGERS WHEN NOT IN USE

eight centimetres with one doffer and two main cylinders, forty-five centimetres with two doffers and one main cylinder, and forty-three centimetres with three doffers.

All vacuum dust extractors used in card stripping are also applicable for removing loose "fly" from the external surfaces of machinery in card rooms. Flexible tubes are obtainable of any required length, and these will penetrate crevices and corners where hands with brushes might be in danger.

THE INCREASE OF AGRICULTURAL EFFICIENCY

By Oskar Nagel

THE body of every plant, of every leaf, every fruit, every tree is built up from two sources—the atmosphere and the soil. The component which is absorbed from the atmosphere is carbon dioxide, a gas which makes up 0.03 per cent. of the atmosphere. This gas is identical with the gas obtained by burning coal or heating limestone, and is exactly the same gas which is used in the manufacture of seltzer water. The flesh of the plants is built up by the products of transformation of this gas.

The components absorbed from the soil make up the bones and skeleton of the plants. And these bony substances—potash, phosphoric acid and ammonia—are left as ash if we incinerate a plant.

What the plant needs, accordingly, is not only atmosphere and soil, but carbon dioxide, potash, phosphoric acid and ammonia. And if these essential plant foods are supplied at all, the plant will grow. It is not essential that the carbonic acid be supplied from the atmosphere, nor that the other substances be furnished by the soil. The atmospheric and soil constituents may just as well be supplied by a uniform solution in which the plant is submerged entirely, or the soil substances may be absorbed from a solution, while the carbon dioxide is taken from the atmosphere.

In this respect the plants growing in the depths of the ocean and the vegetation on the surface of lakes are interesting examples. For the sea plants, the sea represents *the* food solution which supplies all the necessary constituents. Ocean water does indeed contain all the essential food elements. On the other hand, we see that the plants in lakes take the fleshy food from the atmosphere, the bony food from the lake.

By means of these foods alone, however, a plant cannot live nor grow. They need besides a supply of energy in order to enable them to transform the crude food elements into the wonderful variety of delicate substances which we afterwards find in every product of vegetation. This energy is supplied by the light of the sun.

Of sunlight and atmosphere there is always a sufficient supply. Not so with the bony substances that are taken from the soil, the potash, the phosphoric acid and the ammonia. These bone-building substances taken up by the plants are removed in the harvested products, and, therefore even a most fertile soil gets sterile in the course of time. As bony food becomes more and more scarce the plant bodies become weaker and weaker.

If the fertility of a soil is to be preserved the farmer must add to his acreage at least such a quantity of bony substances as he takes away in the harvested products. For this purpose he uses fertilizers and manures. This whole process is self-explanatory and self-evident. If a man is served with a quarter of a pound of steak, but wants to eat two pounds, he has got to get some more on his plate. This is a perfect analogy to the fertilizing branch of farming. The farmer cannot expect to get one hundred pounds of potash into his harvest, the product obtained from one acre, if the acre does not contain this quantity of potash.

Just as a weak man will, in most cases, get stronger if he is fed with as much meat, fat and bread as he can digest, so will a plant grow heavier and bigger if it will get as much food as it can use for building up its body.

As regards the bony food supplied by the soil, we can, of course, apply such a quantity of fertilizers that the plant will get as much as it can use. There is, naturally, a limit to these demands, since with a standard supply of carbon dioxide and sunlight not more than a certain amount of soil food can be digested, or, to use the expression of agriculturalists, assimilated.

We could raise larger plants if, together with an increased supply of fertilizers, we could also increase the supply of carbon dioxide. Then the plant would build more flesh and would also be able to use more bones. But since the content of carbon dioxide of the atmosphere is limited and fixed, and since, furthermore, the atmosphere of the farm is open and uncovered, there is no way to increase this amount and content of carbon dioxide. If we would generate a lot of this gas on a farm it would spread all over in all directions, so that hardly anything would be available for the plants. Hence, the only way to utilize the increase of plants and the increased rapidity of growth by means of an increased supply of carbon dioxide is the application of green houses, or, generally speaking, of "covered" farms. The cover must necessarily be of glass, in order to admit sufficient sunlight.

The first experiments along these lines were made by the Polish botanist, E. Godlewski, in 1872. He found that by doubling the content of carbon dioxide in the air the plants will grow twice as fast and in the usual time will be double the usual size.

These experiments prove that the yield of hothouses may easily be doubled by doubling the carbon dioxide content of the atmosphere in the house. This can be easily accomplished by passing a certain quantity of this gas through the hothouse, either from a bomb containing liquid carbonic acid, such as is used by restaurants in the handling of beer, or by generating the gas constantly in small quantities by the action of sulphuric or muriatic acid upon limestone or marble. It is by no means difficult to control the content of the atmosphere and to regulate exactly the quantity of carbonic acid present by means of automatic regulators, such as are used for the analysis of furnace gases.

We have now arrived at the result that plants may be grown twice as fast as on the open farm. But even so, they only grow during the hours of sunshine. But the chemists, botanists and agriculturists are insatiable people. They wanted the growth to go on also during the night. They tried to obviate the effects of the darkness by applying electric light. They did not rest until they had arrived at a *continuous* growth of the plants. They were finally successful in substituting arc light for sunlight.

This first application of electricity soon led to others. They tried passing weak electric currents through wires in and above the soil, and it was found that this method was indeed of the greatest advantage for increasing the growth. The effect of these weak currents was explained by the theory that the increase of growth was caused by the increase of the availability of the soil foods. By means of these electric currents the plants were fed, so to speak, with predigested food.

The first experiments along these lines were made by William Siemens, in London, and K. S. Lemstroem, in Helsingfors. B. H. Thwaite, however, was the first to make a series of tests combining the use of arc lights and electric currents. He showed conclusively that an electric current led through the soil im-

proves the quantity and quality of the vegetation, destroys the detrimental growth of parasites, and predigests the food, thereby making it more available for the plant. According to Lemstroem's experiments, 10 horse-power are sufficient to supply electricity for 2,000 acres. The commercial success of this method was proved by tests that were undertaken on a large scale in Atvidaberg, Sweden.

In 1902 Pringsheim, a German scientist, showed in Kryschanowitz, near Breslau, that by the application of electric currents to the soil the yield of grain and stalks increased, with barley, 32 per cent., and with oats, 43 per cent., while potatoes increased 24 per cent. and strawberries 50 per cent. In Newcastle a surplus of 37 per cent. was obtained with strawberries, a gain of 20.5 per cent. with peas, while the gain of potatoes was 15 to 30 per cent. In 1903 he obtained a yield increased by 123 per cent. with strawberries, by 32.5 per cent. with barley, by 119.5 per cent. with sugar beets, and by 30 per cent. with beans.

While these figures demonstrate the increased quantity, the improved quality was also demonstrated by these tests. "Electrified" beets contain 2.2 to 2.7 per cent. more sugar than beets raised under ordinary conditions. Electrically-grown rye (Helsingfors) had a protein content of 19 per cent., total nitrogen 19.2 percent., albumen 14.3 per cent. Barley and oats improved correspondingly.

With tobacco, a rich growth and a 26 per cent. increase of the germinative power of the seeds was observed. The roots became exceedingly strong and the color of the leaves very dark.

B. H. Thwaite, in London, made extensive experiments during the last few years with continuous plant growing by using arc lights during the hours of darkness. In order to approach as closely as possible the quality of sunlight, each lamp was provided with a double glass globe half an inch apart, the space between them being filled with water. By passing through this layer of water a part of the light rays is absorbed, just as the corresponding part of the sunlight is absorbed by passing through the atmosphere of the earth. Thwaite's arc lamps move slowly back and forth through the entire length of the building. The experiments covered fuchsia, tomatoes, chrysanthemums, geraniums and ferns. After four nights had elapsed a considerable difference was noticed by comparing these electrical plants with ordinary plants: the electric tomatoes were in the lead by 4 inches and the chrysanthemums by 2 inches.

These facts will convey some idea to the reader as to what can and will be done in the culture of flowers, fruits and vegetables. The value of fertilizers is now fully understood. It will not be many years until the value of the atmospheric fertilizer, the carbon dioxide, which can be gotten almost for nothing, will be fully appreciated. The utilization of the tonic of electricity will then also soon be established. And ten years hence the flower, fruit and vegetable exhibitions of our State fairs will show products of wonderfully large sizes and highest qualities.

THE ECONOMICAL SPEED OF SHIPS

By George Harrison

THE coal consumption and indicated horse-power necessary to propel a vessel at a high rate of speed increase very rapidly with the speed. The rate of increase depends upon the form of the "lines" of the ship; the finer the form or lines of the hull, the less being the power required to obtain a given speed, other things being equal. If, however, the lines are at all full, the extra indicated horse-power required to obtain another knot is large, amounting, in some cases, to as much as 25 per cent. of the total power. The coal consumption may, with sufficient accuracy, be taken as proportional to the indicated horse-power. Hence it is seen that the coal consumption expended in obtaining an extra knot may be disproportionately large. In the case of certain ocean greyhounds the coal consumption is not the most important item, everything being sacrificed for speed. If the speed were properly chosen the coal bill could be reduced by more than one-half, as will be seen in the course of the present article.

In cargo boats, however, the speed is not so important, the coal bill being one of the primary considerations. Hence it is important that the speed should be so chosen as to reduce the coal consumption to its lowest possible limit. In the present article it is proposed to show how this may be effected; also, what would be the effect on the "economical speed" of steaming against or with a current of known force and velocity. Another factor which seriously affects the "economical speed" is the coal used for other purposes than those of propelling the vessel, such as culinary purposes and auxiliary machinery, including electric lighting and steering engines, etc. This will also be considered.

In Fig. 1 the curve *A B* represents, to scale, the curve of indicated horse-power on a speed base for a ship of about 20,000 tons displacement. It will be noticed that when the speed is zero—i. e., when the ship is at rest—the indicated horse-power is 3,200. This means that 3,200 indicated horse-power is used in overcoming the friction of engines and in driving the air and feed pumps, which may be worked off the main engines.

From the curve it will be noticed that to drive the ship at 20 knots requires 22,000 indicated horse-power, whilst to propel the vessel at 10 knots—i. e., at half the first speed—only requires 6,500 indicated horse-power, which is less than one-third that for double the speed.

But in each case we may say that at least 3,200 indicated horse-power is used in overcoming friction of the engines, etc.; hence at 20 knots the net indicated horse-power used in propelling the vessel is 22,000 — 3,200 = 18,800, and at 10 knots is 6,500 — 3,200 = 3,300. The net indicated horse-power, therefore, has to be increased nearly six times in order to double the speed; and in many cases the indicated horse-power has to be increased eight or nine times to obtain the same result.

On the other hand, the time taken to perform a voyage of given distance is only halved when the speed is doubled. Hence, in the above case, on the basis of 22,000 horse-power and 6,500 horse-power, the actual horse-power expended, the coal consumption per hour or per day

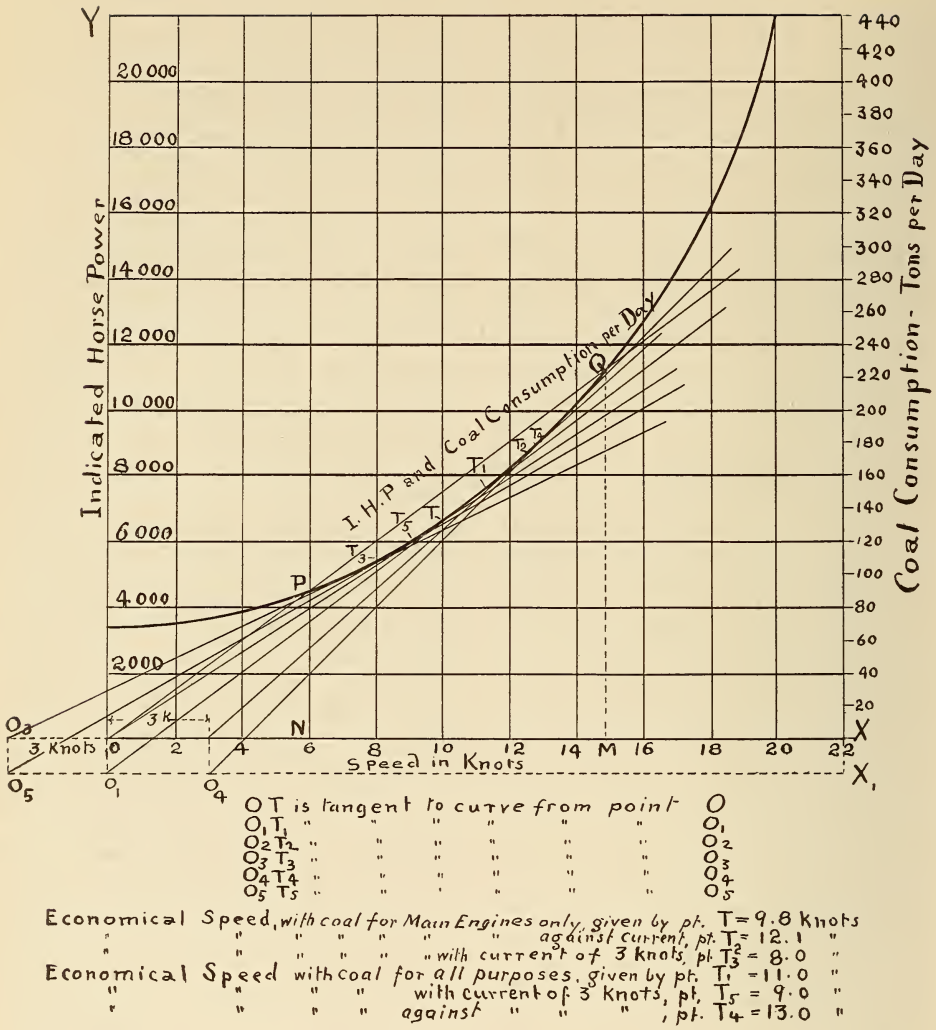


FIG. 1.—CURVE OF INDICATED HORSE-POWER AND SPEED FOR A VESSEL OF ABOUT 20,000 TONS DISPLACEMENT

being taken proportional to the horse-power will be in the ratio 22,000 : 6,500.

The time occupied for the voyage at the higher speed, however, will, as explained, be only one-half that at the lower speed. Hence, for the voyage the coal consumption will be in the ratio $\frac{22{,}000}{2} : 6{,}500$—i. e., in the ratio 11,000 : 6,500, or about 1.7 : 1. It is evident, then, that it is far from economical to perform a voyage at a high rate of speed. Let us now examine the case in which the voyage is performed at a very low speed; for example, say 5 knots in the case of the above ship. From the curve of indicated horse-power in Fig. 1 we see that the indicated horse-power for 5 knots is 4,250. Hence, compared with a speed of 10 knots the coal consumption per day will be reduced in the ratio 4,250 : 6,500. The time occupied for the voyage will, however, be doubled. Hence, the actual coal consumption

at 5 knots for the whole journey will be, compared with that at 10 knots, in the ratio 4,250 × 2 : 6,500; that is, in the ratio 8,500 : 6,500, or as 1.3 : 1. We see that then both at 5 and at 20 knots the coal consumption for a given voyage is greater than that at 10 knots, owing, in the first case, to the greater length of time occupied in making the voyage, and in the second case to the greatly increased coal consumption. Therefore, between the speeds of 5 and 20 knots there is some speed for which the coal consumption for a given voyage is the least possible, and in order to determine this "economical speed" the most obvious way is to plot a curve of coal consumption for the voyage on a speed base. Suppose we take a voyage of 2,400 nautical miles. The curve in Fig. 2 shows the time in days that would be occupied in making such a journey. Also, the vertical scale on the right-hand side of Fig. 1 shows the coal consumption in tons per day on a speed base.

From the curve in Fig. 1, taking the speeds 2, 4, 6, 8, 10, etc., knots, the coal consumption in tons per day is as shown in the following:

TABLE OF COAL CONSUMPTION FOR A VOYAGE OF 2,400 MILES

Speed in knots	2	4	6	8	10	12	14	16	18	20
Tons per day	70	80	93	110	130	165	210	270	335	440
Time occupied in days	50	25	16.6	12.5	10	8.3	7.0	6.25	5.5	5.0
Total coal consumption, tons	3,500	2,000	1,530	1,355	1,300	1,375	1,470	1,687	1,842	2,200

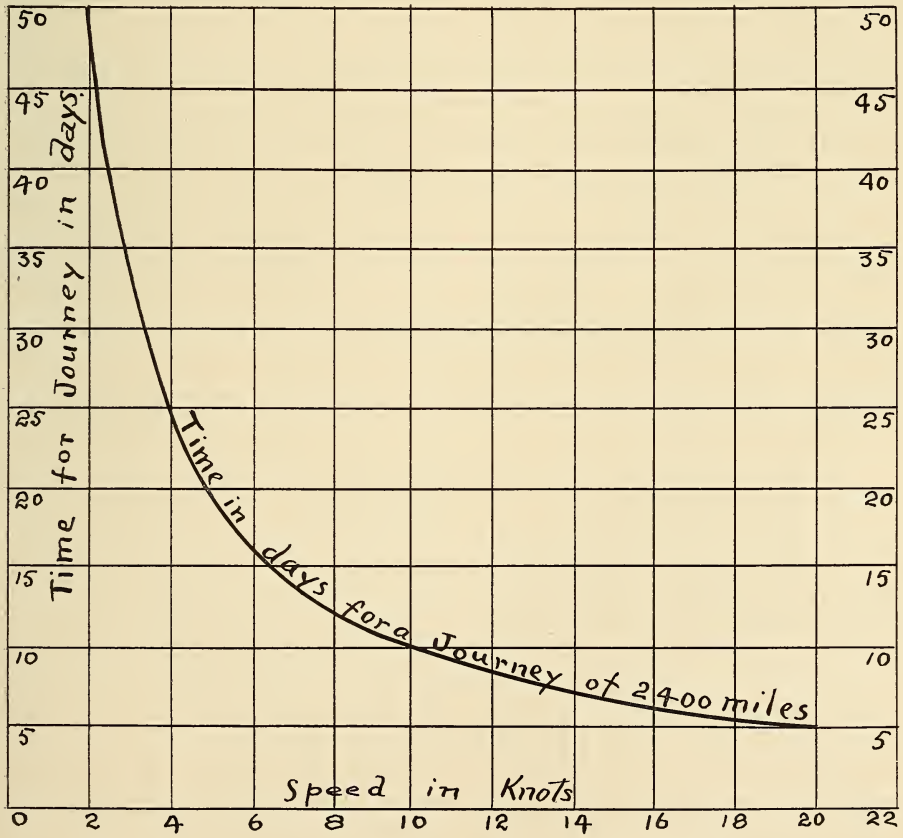


FIG. 2.—CURVE SHOWING TIME IN DAYS TAKEN TO PERFORM A JOURNEY OF 2,400 NAUTICAL MILES ON A SPEED BASE

The last line (total coal consumption) is obtained by multiplying the tons per day by the total number of days taken to perform the journey.

From the totals in the last line it is evident that the economical speed is in the neighbourhood of 10 knots. To obtain its value accurately it is best to plot a curve of total coal consumption on a speed base. This curve is shown in Fig. 3. From Fig. 3 it is seen that the minimum coal consumption is 1,280 tons and occurs when the speed is slightly under 10 knots. The above process, although interesting and accurate, is tedious. The economical speed, however, can be determined in a much more simple manner from the original curve in Fig. 1. It will be noticed that the coal consumption per day is proportional to the indicated horse-power, and that the number of days taken to perform the journey is inversely proportional to V, when V is the speed in knots. Hence, the total coal consumption for the whole voyage is proportional to the product of the indicated horse-power and $\frac{1}{V}$; i. e., to $\frac{\text{I. H. P.}}{V}$.

Thus, at the speed of 6 knots the indicated horse-power is represented by $P\,N$ and the speed by $O\,N$. Hence, by the above reasoning, the total coal consumption per voyage is proportional to $\frac{P\,N}{O\,N}$; i. e., to the "tangent" of the angle $P\,O\,N$.

Therefore, the total coal consumption is proportional to *tan* $P\,O\,N$. Now join $O\,P$ and produce it to cut the curve again in the point Q, and draw $Q\,M$ perpendicular to axis $O\,X$.

Then $\frac{P\,N}{O\,N} = \frac{Q\,M}{O\,M}$; i. e., at the points P and Q on the curve, the ratios $\frac{\text{I. H. P.}}{V}$ are equal.

Hence, at the two speeds represented by $O\,N$ and $O\,M$ the total coal consumption for the voyage would be the same. Now, in general, a line through O would always cut the curve in two points, and hence there are always two speeds for which the total coal consumption on a voyage would be the same. The better speed to adopt is evidently the higher one, since the time occupied would be considerably less.

Again, we have seen that the total coal consumption is proportional to the tangent of the angle $P\,O\,N$. Now, the tangent of an angle depends upon its size, the smaller the angle, the smaller being the value of its tangent.

Hence, the smaller the angle $P\,O\,N$, the smaller the total coal consumption. The smallest angle that can be drawn through O to cut the curve is that whose bounding line touches the curve, such as the line $O\,T$ in the figure, which touches the curve at the point T. Hence, the speed represented by the point T gives the least coal consumption on a given voyage; i. e., T gives the economical speed.

All we have to do, then, in order to find the economical speed is to plot a horse-power curve on a speed base and from the origin O draw a tangent to the curve, the point of contact giving the speed and horse-power desired.

It is sometimes difficult to determine the speed accurately, and in this case, instead of taking a speed base, the revolutions of the engine per minute may be taken as the base with sufficient accuracy.

In Fig. 1 it will be noticed that the point T corresponds to a speed of nearly 10 knots, which is in agreement with the economical speed previously found by actually plotting the total coal consumption on a speed base in Fig. 3.

In the above analysis it will be noticed that only the coal used by the main engines has been considered. In the case of the above ship quite 20 tons per day would be used for other purposes. Hence, the coal

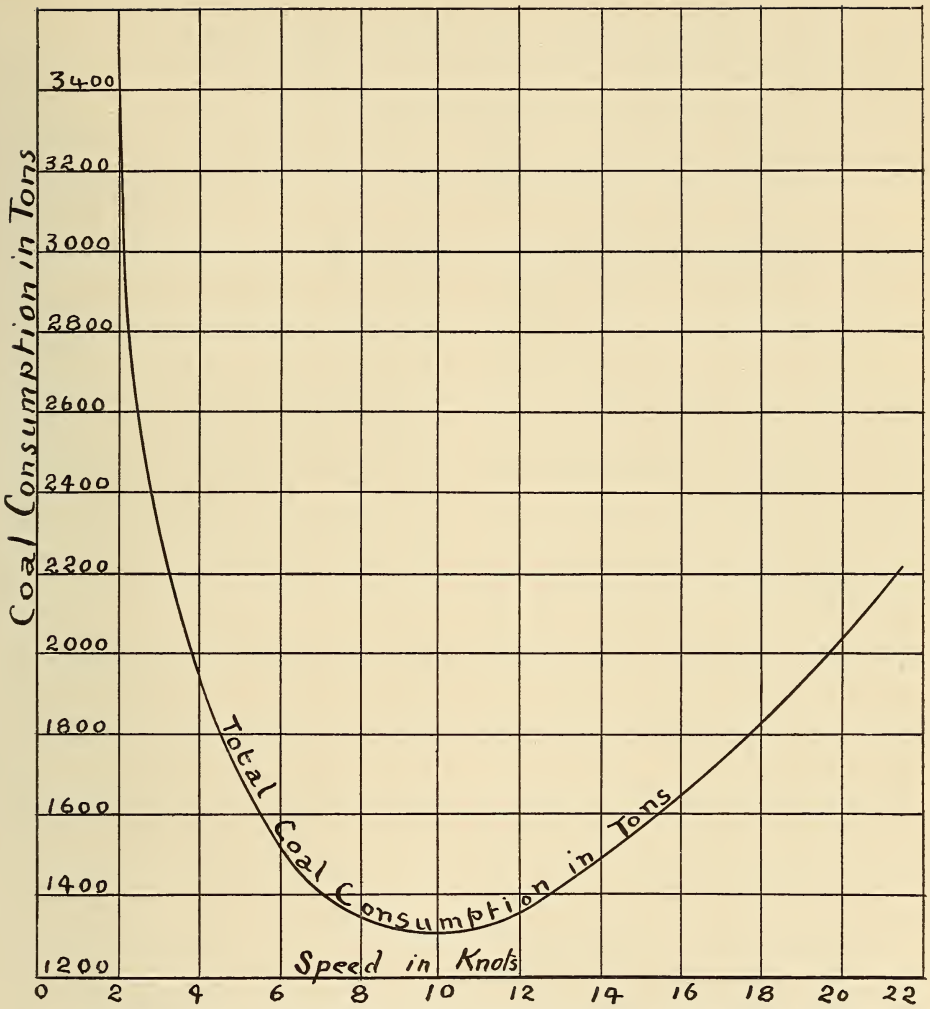


FIG. 3.—CURVE SHOWING TOTAL CONSUMPTION OF COAL FOR A JOURNEY OF 2,400 MILES ON A SPEED BASE

consumption per day is increased by 20 tons over and above that shown in Fig. 1.

To take this into account, set off on the vertical axis $O\,Y$ through O a length $O\,O_1$ downwards to represent 20 tons on the given scale, and draw $O_1\,X_1$ horizontal. Then the total coal consumption per day is given by ordinates from $O_1\,X_1$. Hence, to find the economical speed in this case we must draw a tangent from the point O_1 instead of O. The point of contact in this case would then be beyond T, showing that the auxiliary coal consumption increases the economical speed slightly.

Next let us consider the effect of steaming against a current, the speed of which can be estimated. Suppose the speed of the current to be 3 knots. Then, if the ship were steaming, say, at 12 knots, the speed, if there were no current, would be 15 knots. This means that the horse-power generated by the engines is that necessary to propel the vessel at 15 knots in still water. At 15 knots the indicated horse-power from

the curve in Fig. 1 is 11,500; therefore, when steaming against the above current, the speed will be 12 knots, but the horse-power required will be 11,500. This means that the horse-power curve on a speed base will be considerably raised and the point of contact of the tangent from O will be more to the right, showing the economical speed to be increased. The same result, however, can be arrived at in a more simple way, as follows:

From O set off along $O X$ the length $O O_2$ to represent the speed of the current, $= 3$ knots, to the scale of V. Then if, instead of measuring the speed from O we measure it from O_2, the curve of Fig. 1 will not need to be altered. Thus, measuring from O_2, the speed of 12 knots corresponds to that of 15 knots in still water, and the indicated horse-power at 12 knots against the current is 11,500, as it should be. To find the economical speed in this case, we must draw the tangent from the point O_2.

Finally, suppose the ship steams with a current of 3 knots. We must then mark off a length $O O_3$ to represent 3 knots in the opposite direction, as shown, and draw a tangent to the curve from the point O_3. By taking the points O_2 and O_3 on the axis through O means that the coal used for auxiliary purposes has not been considered. To take the latter into account, we must measure the lengths $O O_2$ and $O O_3$ on the horizontal axis through O_1, obtaining the points O_4 and O_5, respectively. The new economical speeds, given by the tangents through O_4 and O_5, respectively, will be seen to be considerably increased.

MODERN TESTING MACHINES

PART I.—TENSION, COMPRESSION AND BENDING

By C. A. M. Smith, M. Sc.

ALL materials used in engineering and constructional work must be selected from considerations of their strength, and so proportioned as to stand successfully the forces to which they are subjected. It is of advantage that all metals do not possess the same qualities as regard strength, for while one is suitable under one condition it may be quite unsuitable under another system of loading. The safe load to which a material may be subjected must, therefore, be known with some certainty; otherwise, in the building of machines and structures, collapse may take place, owing to insufficient material being employed, or too much may be used, thus increasing the cost if the conditions are not known. Engineers have found that the only satisfactory way of determining suitable safe loads in design work is to take specimens of the material to be used and subjecting them to tests which reproduce, as far as possible, the actual conditions in practice. Experiments of this kind are made in various types of testing machines. Some machines are designed to test the properties of materials subjected to only one kind of straining action. Given such conditions, the machine would be of simple construction. If, however, a machine is to be used for investigation into the behaviour of materials under different straining actions, it becomes more complicated. Testing machines are, therefore, simple or complex in construction, according to whether they are used for a few or a greater number of purposes. It is usual to build testing machines which can be adapted by slight modifications to test materials in tension, compression or bending. Machines of this type are usually made in sizes to test with loads up to 50 or 100 tons.

The simplest method of determining the tensile strength of a material would be to take a prepared specimen, suspend it vertically from one end and hang weights on the other end until it breaks. The total load would be the breaking load for the particular specimen. Knowing the cross-sectional area, the breaking stress can be determined. In a similar way the strength of specimens subjected to compression and bending could be investigated. This method is crude, and only specimens of extremely small cross-section can be employed. By interposing a lever between the load and the specimen the weight required is reduced in the ratio of the leverage. Below is given a description of a simple form of testing machine. The specimen of the material to be tested consists of a truly turned cylindrical bar, one end of which is gripped in a pair of jaws fixed to the framework of the machine, while the other is attached to the short end of the lever. A weight is allowed to slide along the long arm of the lever so that its distance from the fulcrum can be varied at will. At the commencement the weight is near the fulcrum. The weight is then run slowly out towards the end of the lever, and so the load is gradually applied until the specimen is broken. The breaking load is then given by the moving weight on the long arm multiplied by its leverage. A practical difficulty is here encountered. If the specimen always

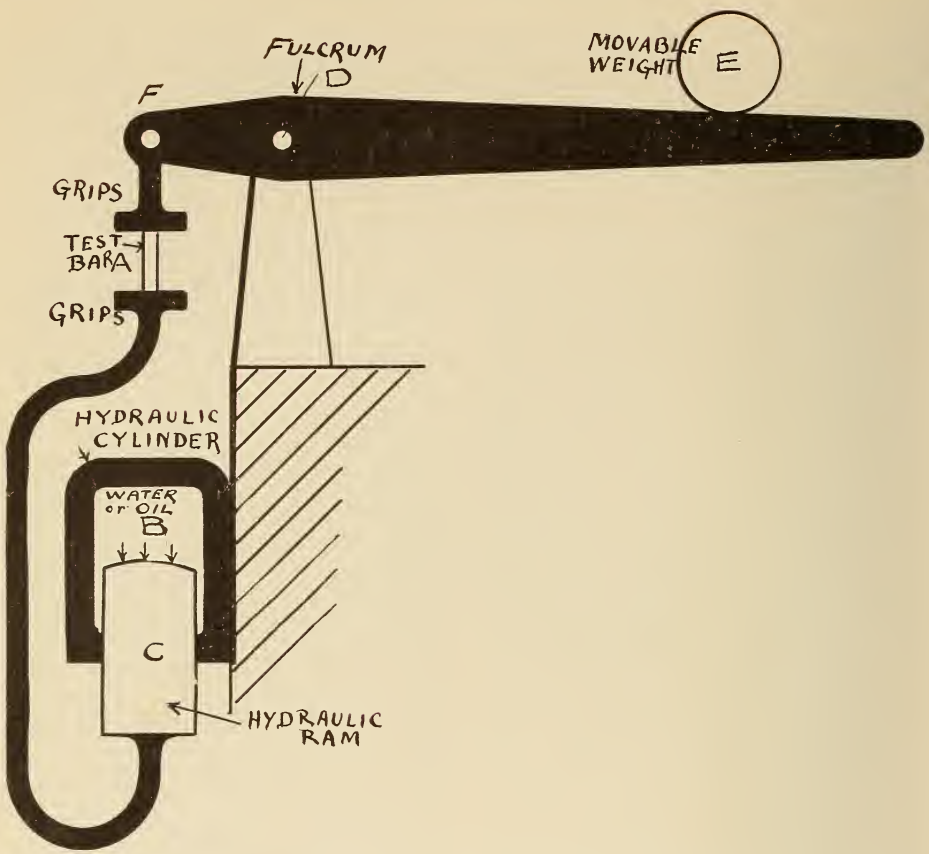


FIG. 1.—DIAGRAMMATICAL SKETCH OF VERTICAL TYPE OF TESTING MACHINE

remained of the same length the lever would always be of the same effective length, since it would always be horizontal. On the application of the load the specimen is more or less deformed, according to the material. This causes the position of the lever to be altered, the deviation increasing with the leverage. The lever thus assumes an oblique position and tends to bend as well as stretch the specimen. It is, therefore, necessary to take up the stretch in the material so as to keep the lever horizontal. This is usually done either by means of an hydraulic ram or a screw. It requires no great effort of imagination, now that we have reached this point, to assume that the ram or screw produces the pull, while the movement of the weight along the lever gives us a method of measuring the load so produced. Most modern machines are arranged in this way, though gearing is sometimes used instead of the hydraulic ram, and a manometric arrangement is employed instead of the lever.

VERTICAL TESTING MACHINES

There are two types of testing machines, vertical and horizontal, so termed, accordingly, as the specimen is secured in a vertical or horizontal plane. A vertical testing machine is shown diagrammatically in Fig. 1. The test bar *A* is held suitably in grips in a vertical position, the load being applied by means of the hydraulic ram *C* working in the cylinder *B*. Water or oil under high pressure (2,000 to 3,000 pounds per square inch) is forced into the cylinder *B* and causes the ram *C* to

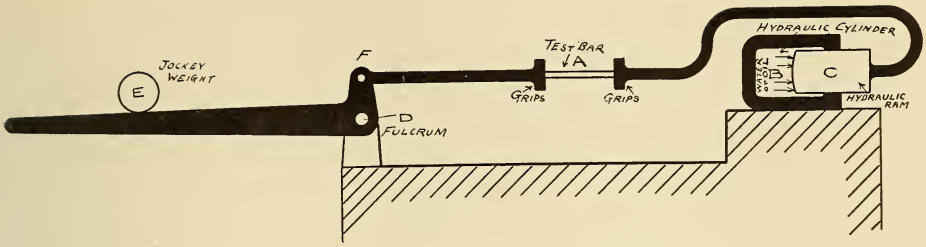


FIG. 2.—DIAGRAM SKETCH OF HORIZONTAL TYPE OF TESTING MACHINE

move downwards. The tenacity of the specimen opposes this downward pull. Owing to the friction of the cup leathers which are employed to prevent leakage of the working fluid, the pressure in the cylinder cannot be taken as a true measure of the load applied. The upper end of *A* is, accordingly, fastened by means of similar grips to the shorter arm *F* of the lever, whose fulcrum is fixed at *D*. On applying the load the end *F* tends to move downwards. This is counterbalanced by running the movable jockey weight *E* along the longer arm of the lever or "Stillion." In this way the lever is always kept horizontal, in accordance with the statements made above. The length of the stillion is usually so calibrated that from the position of the weight along the arm the load on the specimen may be read off directly.

THE HORIZONTAL TESTING MACHINE

In Fig. 2 is shown a horizontal type of testing machine. It is precisely the same in principle as the vertical machine. The load is applied, as before, by means of an hydraulic ram. Instead of being straight, the lever is in the form of a bell crank, the horizontal pull on the specimen being balanced by the vertical action of the weight.

THE WICKSTEED TESTING MACHINE

Some of the more important machines for testing the strength of materials in tension, compression and bending may now be considered. One machine can, as a rule, be easily adapted for testing under all these conditions, although different grips and specimens have to be employed. The Wicksteed machine is a well-known design, the principle of working of which is shown diagrammatically in Fig. 3. Water or oil is first admitted to the compressing cylinder, the ram of which is screw-driven. This fluid, under pressure, is then admitted through a valve into the hydraulic chamber, which is usually secured in an inverted position to the base of the machine. Acting downwards on the ram the pressure is transmitted through the lower crosshead to the adjusting screws and thence to the upper crosshead, which carries the lower grip and usually slides in a guide attached to the main frame of the machine. The upper grip is connected by means of a shackle to the beam through a knife-edge. The lever, which is usually made of cast iron, rests on top of the standard, being supported on knife-edges. A screw traversing the whole length of the beam serves to move the jockey weight along. The weight carries a vernier, which moves along a scale fixed to the beam, so that the position of the weight, and, consequently, the load applied, can be read off very precisely. Stops are provided to limit the tilting motion of the beam. The object of the adjusting screws is to enable the distance between the grips to be adjusted to suit the length of specimens. In the diagram the machine is shown fitted up for tension tests. A slight modification is necessary, however, for compression testing. A square plate replaces the lower grip, and a similar

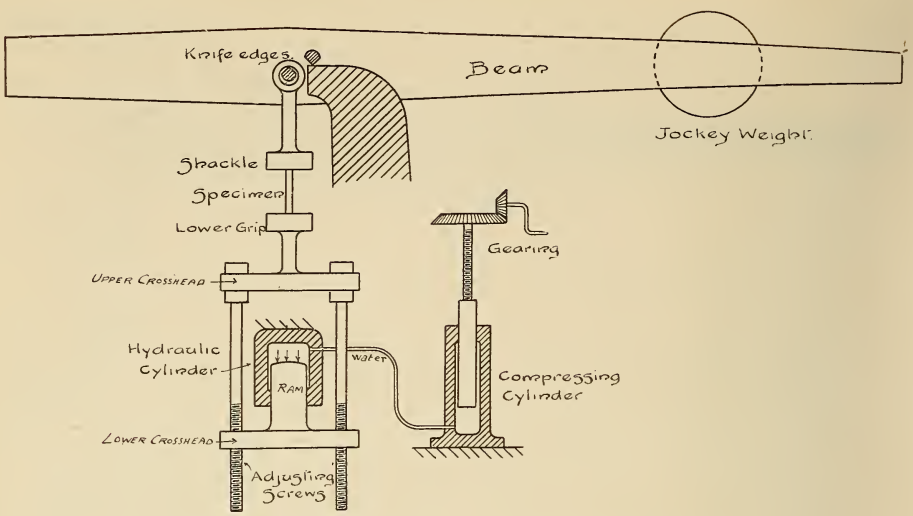


FIG. 3.—PRINCIPLES OF WORKING OF THE WICKSTEED MACHINE

plate is suspended some distance below by four stout bars from the upper shackles, the load thus being applied to the same point in the beam as in the tensile test. Consequently, the lower shackle in the latter test now acts as the upper one, and vice versa. If a test piece is placed in between the two hard steel plates the direction of the stress is reversed and the material is compressed. The compression load is measured in exactly the same way as before.

THE KENNEDY MACHINE

This type of horizontal machine is shown in Fig. 4. The ram of the hydraulic cylinder *A* is connected to a cast-iron sliding frame *B*, which carries an adjustable crosshead *C*, in which is fixed one set of grips for the test bar. The other crosshead *D* is fixed between two screwed bars *E*, which traverse the whole length of the machine. If a tensile test is to be performed the specimen is gripped between these two crossheads. To adjust the distance between them, the key which fastens the movable crosshead *C* to the sliding frame *B* is drawn out, the crosshead moved to the required distance, and the keys replaced. The frame has keyways cut in it at intervals of about 4 inches to allow this crosshead to be fixed in any position. For compression tests, a flat plate is provided at that end *F* of the sliding frame

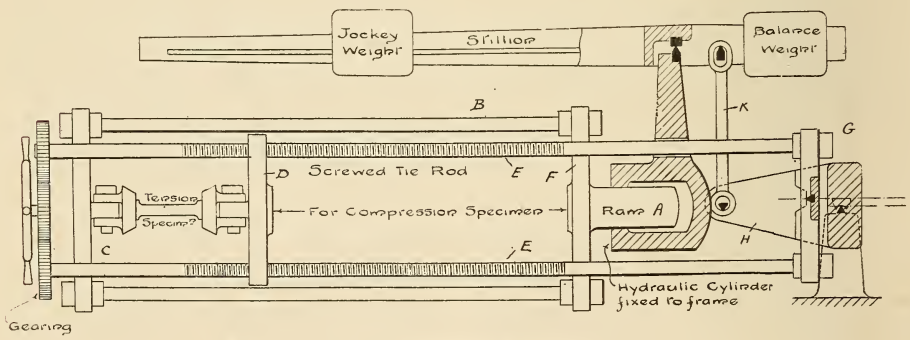


FIG. 4.—DIAGRAM OF THE KENNEDY TESTING MACHINE

which is nearest to the ram and a similar plate on the fixed crosshead *D*, the specimen being gripped between them. The screwed rods which transmit the stresses to the levers are thus always in tension, the sliding frame being similarly invariably in compression. The tension is transmitted to the back crosshead *G*, which, through knife-edges, actuates two side levers *H*. Force being applied to these levers at a point above the fulcrum gives the effect of a bell-crank lever, so that the direction of the forces is changed from horizontal to vertical. This is invariably the case with horizontal testing machines, as we wish to balance the forces by means of a sliding weight whose direction of action is, of course, vertical. The outer ends of these side levers are connected by means of tension rods *K* to the short arm of the beam, the forces being measured by running out a jockey weight in the usual way.

THE AMSLER TESTING MACHINE

This machine, shown in Fig. 5, differs from any that we have hitherto mentioned by reason of the fact that no beam or weight is used to measure the applied load. Great care is taken in machining the cylinder *A* and its ram to ensure a perfect fit, so that no cup leather or other packing is necessary to prevent leakage. The friction due to the cup leathers being eliminated, the pressure inside the cylinder may be taken as a measure of the load on the test bar. Oil is forced from the compressing cylinder *B* into the hydraulic cylinder *A*. The pressure from *A* is transmitted by means of a pipe *D* to the cylinder *C*. As this pressure is high, no mercury column of convenient height could be used to record it. Accordingly, it is caused to act on the ram *E*, which actuates the plunger *G*. We thus obtain a reducer, the pressures per square inch in *C* and *F* varying inversely as the areas *E* and *G*. The pressure exerted by the plunger *G* is balanced by the mercury column *H*, which is calibrated to read directly the load on the specimen. In some cases the maximum power of the machine is not required, so that greater accuracy in read-

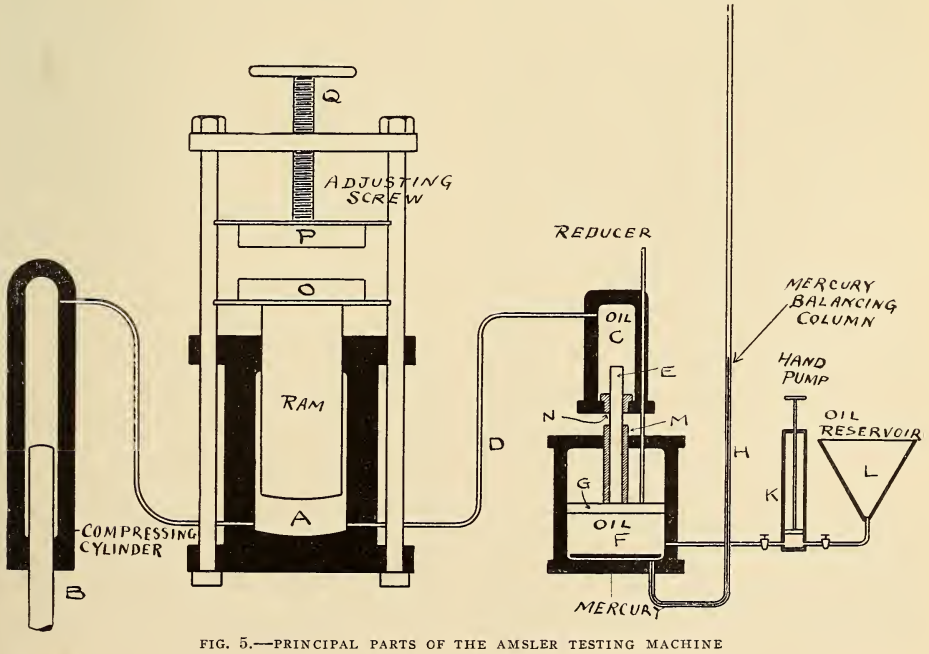


FIG. 5.—PRINCIPAL PARTS OF THE AMSLER TESTING MACHINE

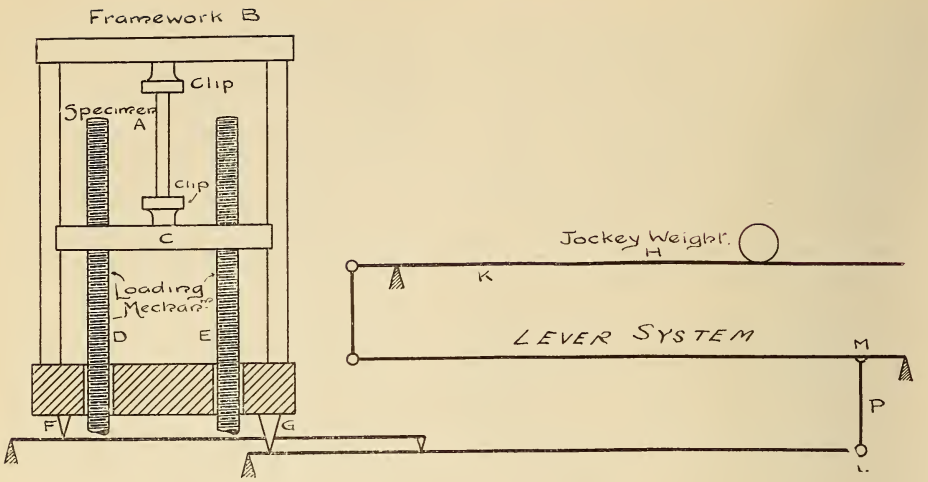


FIG. 6.—THE RIEHLE TESTING MACHINE

ing the loads on the specimen is desirable. The ratio of reduction in the reducer is then diminished, as follows: Oil is pumped into *F* by means of the hand pump *K*. In this way the plunger *G* is raised until the sleeve *M* comes in contact with the ring *N*, raising it off its seating. The effective area on which the pressure in *C* is acting is now increased. Consequently, the pressure in *F* is more nearly equal to that in *C* than it was before, owing to the smaller reduction ratio. The mercury column *H* is made longer, and thus more sensitive to the rise of pressure in cylinder *A*, the arrangement being equivalent, in fact, to an enlarged scale of loading. To eliminate friction as far as possible in the reducer, the plunger and piston are given a backward and forward rotation by means of linkwork actuated from the main compressor. The specimen to be tested is placed between the tables *P* and *O*, adjustment for length being made by means of the handwheel *Q*.

RIEHLÉ TESTING MACHINE

In the Riehlé machine, Fig. 6, we again revert to the jockey weight and lever as a method of measuring the load on the test bar. The loading mechanism in this case, however, consists, not of a cylinder and ram, as in previous cases, but of two strong screws *D* and *E*, which pass vertically through the machine. These screws are rotated (through gearing which permits of several speeds being used) by an electric motor, and pass freely through the bed of the frame. The specimen *A* is held by clips to the framework *B* and the table *C*, the latter being moved up or down by rotating the screws *D* and *E*. The whole framework *B* rests on a system of levers, to which the load on the specimen is transmitted through knife-edges at *F* and *G*. Balance is effected by the jockey weight *H*, which moves along the graduated stillion *K*. The pull *P* in the connecting-rod *M L* does not depend on the relative loads on *F* and *G*, but merely on the total load on the knife-edges. Consequently, the accuracy of the machine is not affected if the specimen is unsymmetrically placed in the grips. There are several special features about machines of this type. Placed between the driving pulley and the screws is a system of change gears giving eight speeds, forward and reverse (i. e., tension or compression). By this means the machine can be set or changed over from a tension to a compression test in a short time

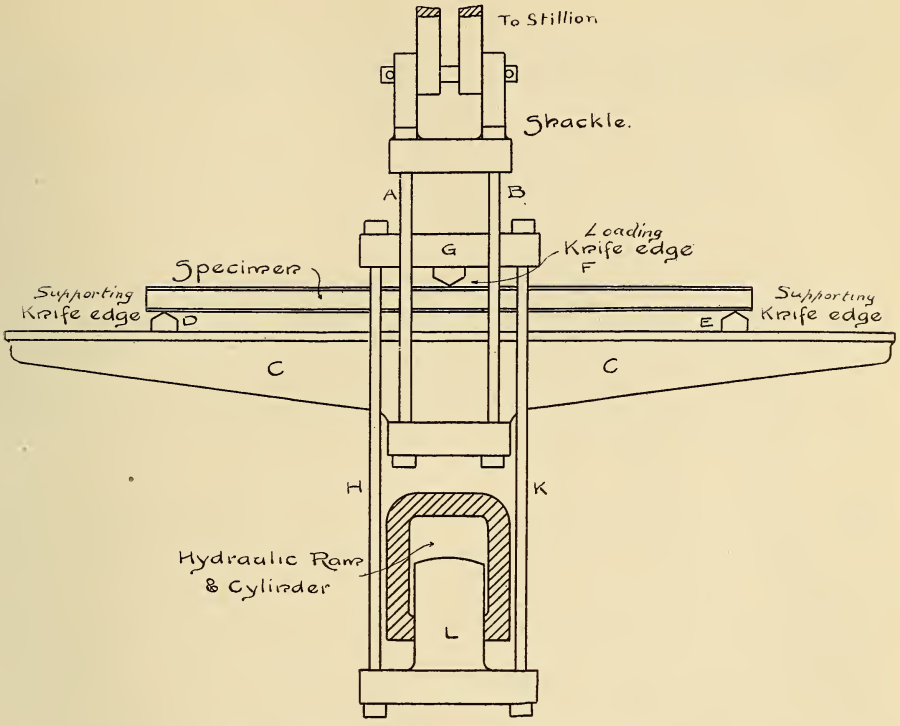


FIG. 7.—GENERAL ARRANGEMENT FOR TESTING GIRDER

without any manual labour on the part of the experimenter. To develop full advantages of this machine, the whole is run as fast as possible, thereby necessitating considerable care and experience in changing the gears. It is sometimes urged against this type of multi-lever machine that wear and friction render it less accurate than single-lever machines.

ARRANGEMENT OF MACHINES FOR BENDING TESTS.

So far, the machines considered have been described for tension and compression tests only. They can, however, all be used for bending tests by using additional apparatus. Fig. 7 shows the arrangement of a vertical testing machine for testing girders, etc., in bending. Connected with the stillion knife-edge by means of four tie-rods *A* and *B* is a table *C*, with a flat, machined face. This table *C* is detachable, and is removed when performing other tests. Two knife-edges *D* and *E* are bolted to this table in such a way that their distance apart can be adjusted to suit any size of specimen within the limits of the machine. These knife-edges often rest on spherical seats, which adjust themselves as the load is applied, so that the supporting forces are exactly vertical in direction. The specimen to be tested rests symmetrically across these knife-edges and is loaded at the centre by means of a knife-edge *F*. The ram *L* is forced downwards by the water in the hydraulic cylinder and the load transmitted by means of tension bars *H* and *K* to the knife-edge *F*. The breaking load is measured in the usual way by means of the jockey weight traversing the long arm of the stillion. Horizontal machines can be adapted to take specimens for bending in a similar manner, although they are less convenient.

MECHANICAL APPLIANCES ON THE PANAMA CANAL

I.—THE TASK TO BE ACCOMPLISHED

By J. F. Springer

The engineering operations involved in the construction of the Panama Canal have been frequently discussed, and in general it may be said that they include little which is new in itself. It is true, however, that nearly every mechanical appliance which has been employed in the work on the Isthmus has been improved and developed in the effort to meet the demands which that great work has made. It is undoubtedly true that the entire field of mchanical equipment has been stimulated by the requirements which the completion of the Panama Canal has initiated, and that when any similar work elsewhere is to be built, the capacity of the available apparatus will be found to have been so increased by the experience at Panama that all previous estimates of time and cost will have to be revised. It is the intention of this article, and those which will follow it, to discuss the character of the undertaking and the equipment by which it has been achieved in the light of the influence which the work itself has made upon the apparatus by which it has been effected.—THE EDITOR.

NEARLY all the land in the world is in the northern hemisphere. One who traveled around the Arctic Circle could make the journey almost entirely on land. There would be but one considerable interruption—between Europe and North America. And yet access by the sea can be obtained to the Arctic Ocean not only here, but also between North America and Asia. Were it not for climatic conditions, a great deal of maritime traffic could readily be carried on between all the continental masses of the northern hemisphere. A very suitable sea route from New York to Hongkong would be by way of the North Frigid Zone. Similarly, one could go by sea route of not unreasonable length from London to San Francisco by sailing into the Arctic Ocean. But the climatic conditions do exist which prohibit the use of the waters of the extreme north. If one seeks the southern possibilities, he finds at once that there are two very considerable continuations of the northern land masses towards the south. And so it comes about that very little of the world's traffic can be economically carried on by way of the Cape of Good Hope or Cape Horn. In the latter part of the nineteenth century the necessity of rounding the former of these continental terminal points was eliminated by the construction of the Suez Canal. In a very short time now, if no untoward event occurs, the rounding of Cape Horn will no longer be a necessity, except, perhaps, for traffic bound to or from southern points in South America. The Panama Canal is approaching completion, and will soon become a great fact in world commerce.

North and South America are two continental masses of the same general form. Both are, if one speaks in a large way, triangles, with the bases towards the north and the vertical angles towards the south. The vertex of one is on the base of the other. But South America is set further eastward, so that the tapering portion of North America curves in a great bend in an easterly direction to make connection with the southern continent by a somewhat sinuous strip of land, which is reckoned a part of South America. This strip of land is the Isthmus of Panama. The greater portion next the continent is in the form of a semicircle. The convexity is towards the north. A little to the west of the northern summit of this bend is the site of the canal. The great waterway will not run from east to west or the reverse. On the north is the Caribbean Sea, a part of the Atlantic Ocean. On the south is that arm of the Pacific known as the Gulf of Panama. The route is by no means

a straight line; but, looking on it as such, the general direction is, roughly, northwest and southeast. One who passes from the Atlantic to the Pacific will, accordingly, travel southeasterly. The site chosen is not the only possible one; nor is it the shortest. The problem—for it was a problem—was not such a simple one as to find the region of closest approach of the two oceans and then cut a ditch connecting them. This was the case at Suez.

The great ridge which extends from Alaska southward and which in the United States is known as the Rocky Mountains Highland, is really continuous with the immense pile of rocks called the Andes Mountains. No doubt the same group of elemental geologic causes has produced the whole mountain chain, extending from the Arctic Ocean in the north to the vicinity of the Antarctic Ocean in the south. At the Isthmus it is by no means a noble mountain range. Still it is a formidable barrier to canal construction. When Balboa crossed the Isthmus in 1513 and became the first European certainly known to have laid eyes upon the great Pacific, he followed one of the shortest routes. This, however, is not the one chosen for the canal. The waterway follows pretty closely the route taken by Morgan when he led his piratical crew upon the old city of Panama. This was more than two centuries ago. Even then the city was a considerable one, and was the port through which a fine commerce in gold, silver, pearls, etc., passed on its way to Europe. The city was pillaged and burnt. In the rebuilding which followed, because of its logical situation at the gateway between the Old and the New Worlds, a somewhat different site was chosen. The new city arose upon a coral formation which juts out into the Gulf of Panama. At a cost of much treasure great walls were constructed and a moat provided.

The ruin of the days of Morgan has never revisited the new city. The canal follows his route, however, and terminates on the Pacific side near the sites of the old and the new cities of Panama.

From shore to shore the canal will be 40 miles in length. But a vessel will have a passage 10 miles longer from deep water to deep water. The highest point of the intervening ridge is 534 feet above the sea level. This is at Gold Hill, in the now celebrated Culebra region. As the bottom of the canal is here to be about 40 feet above the sea, it is readily seen that excavation to a maximum depth of about 500 feet below the surface will have to be accomplished. But this excessive depth is required only at one point. However, at another point in the neighbourhood a depth of about 375 feet is required. The canyon being constructed through this highest region of the ridge is Culebra Cut. It occupies about 9.5 miles, or 24 per cent., of the total length of the canal from shore to shore. The amount of excavation here amounts to about 108,775,000 cubic yards. When completed, it will probably be by far the greatest piece of dry excavation ever performed. The French, who preceded the Americans now operating, excavated about one-fourth of this amount. On October 23, 1909, or a little less than five and one-half years after they began, the Americans had excavated 39,002,000 cubic yards and thought they were half through. But they were something short of having one-half done. Their calculation then was based on a different total. The French had been at work presumably about sixteen years in all, leaving out of account the period between 1889 and 1895.

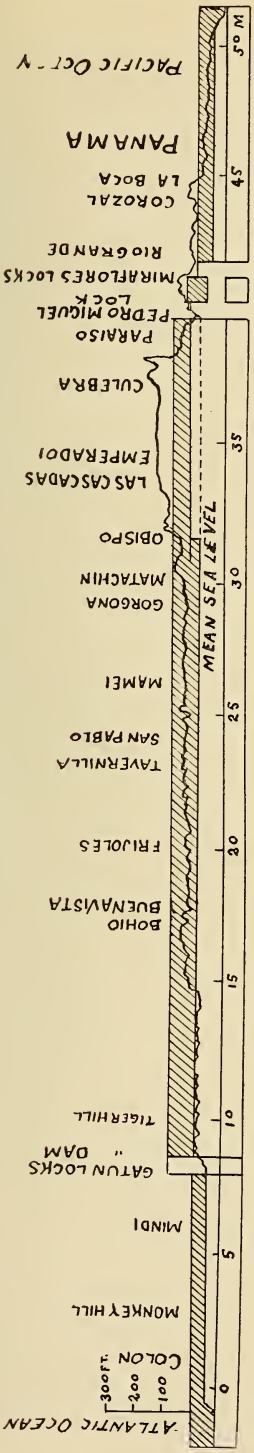
The surface level of the water in Culebra Cut is to be at 85 feet above mean sea level. This level will obtain not only through the cut itself, but for about 22 miles northwestward, in the direction of the Atlantic, to the Gatun locks. These 32 miles

between this point and the Pedro Miguel lock at about the southeastern end of the cut constitute the high level portion of the canal; that is to say, three-fourths of the length between shore lines will be at a single high level. On the Atlantic end about 2½ miles will be at the sea level; on the Pacific end, about 1 mile. The remaining 4 or 5 miles will be taken up with a short length of intermediate level and with the various locks. The Panama Canal will, accordingly, have three distinct levels.

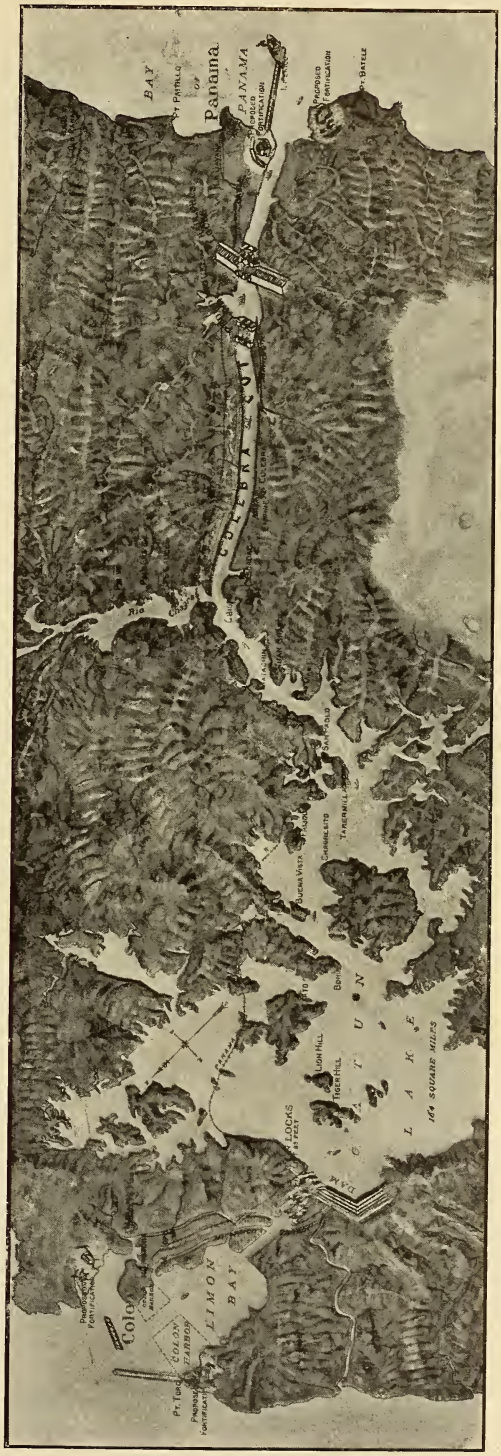
We must not imagine that the canal will be a narrow strip of water extending from ocean to ocean. Between the Gatun locks near the Atlantic end and Culebra Cut will be Gatun Lake. This body of water will be produced by the dams and locks at the termini of the high level section. Through Culebra Cut the canal will indeed be a narrow streak of water, but northwards will be the lake proper, a body of water having a superficial area of 164 square miles. This is quite a considerable sheet. Its outline is most irregular. The canal through this region will take the form of a submerged channel. Throughout the total high level section the depth of water in the canal will be 45 feet or more. Through Culebra Cut the minimum width at the bottom will be 300 feet.

The Americans, as has already been intimated, were not the first to enter upon this construction. The French had brought to a successful consummation the digging of the Suez Canal in a period of ten years. This waterway connecting the Mediterranean and the Red Seas required the excavation of a channel nearly 100 miles in length. When first constructed, however, the bottom width of the channel was only about 72 feet. The depth was 26 feet. These dimensions are so insignificant when compared with the 40 or 45 feet of depth of the Panama Canal and the minimum width of 300 feet that the difference in length is much more than swallowed up. Moreover, the construction of the Suez Canal presented but few great problems of an engineering character. The Panama Canal has involved many. The waterway of the Old World was little more than a digging proposition. However, the French, having made a success of the one enterprise, undertook the other with their accustomed enthusiasm. They did not understand the formidable character of the work before them. Lest we may disparage them overmuch, let it be said at once that on January 1, 1880, when the first stroke of the pickaxe was made, they knew, perhaps, as much as any other nation of what was ahead. They failed, and probably no other nation would at that time have succeeded. The world was not yet ready for the gigantic task. The French formed two companies. The first became bankrupt in 1889. It would seem that this company deserved to fail, because of incompetence or graft, or both. However, it accomplished pretty much all the excavation antedating American control. The second company began work about 1895 and continued operations for about ten years. But while this may have kept the company alive, it did not result in any great advance in the real work of construction.

When, on May 4, 1904, the Americans took over the control, it is possible they did not realize fully the character of the work they had undertaken. The Americans were, however, better situated than the French. They were closer at hand; the United States Government was the constructor, and the development of mechanical methods and appliances was in a far different stage of advancement in 1904 than in 1880. There is, probably, no appreciable amount of graft affecting the constructional, sanitary and administrative departments. The work is going ahead with great certainty and dispatch. It is confidently expected that the canal



PROFILE OF THE PANAMA CANAL



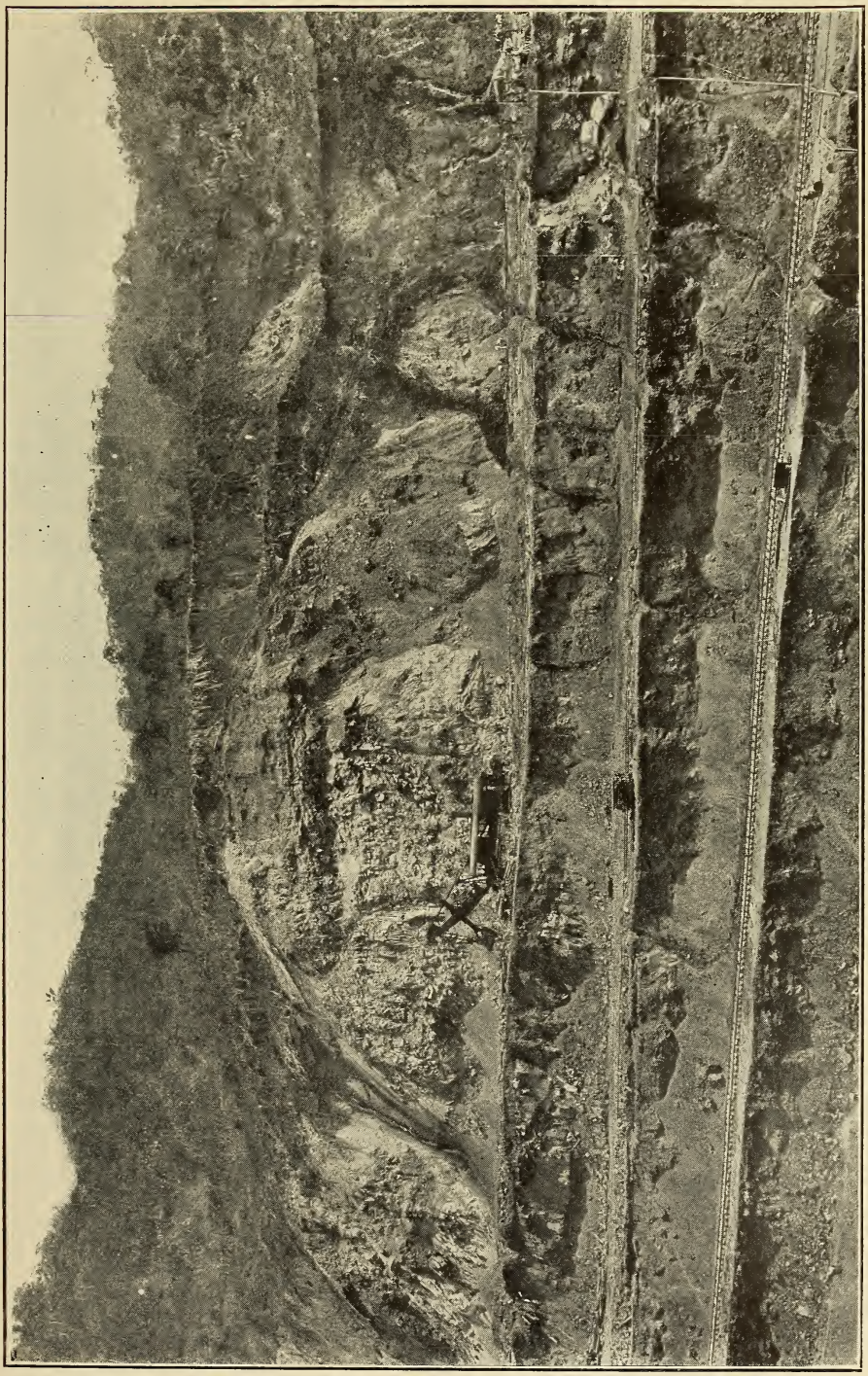
TOPOGRAPHICAL VIEW OF THE PANAMA CANAL

will be completed by January 1, 1914. If so, the Americans will have occupied a little less than ten years in carrying the work to a successful conclusion. That the confident expectation is well founded may be illustrated by the amount of excavation completed in Culebra Cut. The fiscal year 1910-1911 closed on June 30, 1911. At that moment the Americans had completed 78 per cent. of what they undertook in 1904. The number of cubic yards still remaining unexcavated were 18,672,000. In the seven years and two months preceding July 1, 1911, the Americans excavated from this region a total of 65,515,000 cubic yards. This implies an average rate of 761,800 cubic yards per month. If we estimate that the number of working days from May 4, 1904, to June 30, 1911, is 2,242, then the daily average was 29,222 cubic yards. The yearly average was about 9,141,609 cubic yards. This warrants us in expecting the completion of Culebra Cut not later than the middle of July, 1913. Indeed, this is an extreme date; for, despite the fact that the deeper excavation is the harder, the rate of progress per year has been on the increase from the start. The fiscal year ending in 1911 saw more excavation than any of its predecessors. The amount was 16,221,672 cubic yards, which was an advance of 25 per cent. over the excavation accomplished in the year ending in 1908. The rate at which excavation was accomplished for the fiscal year prior to July 1, 1911, warrants us in expecting the completion of Culebra Cut as early as August, 1912.

It is said that the excavation per shovel has increased. This has given rise to a decrease in the cost per cubic yard, as may be seen from the following comparison: Excavation in the central division, in which Culebra Cut is located, for the whole period of American occupation ending March 31, 1911, cost 88 cents per cubic yard. But the cost during the final three months of that period was only 57 cents per cubic yard. This is a saving of more than one-third. The increase in economy is ascribed "to the increasing effectiveness of the working force." The three months ending June 30, 1911, showed a total excavation amounting to 4,278,626 cubic yards, costing $2,693,027.61. The average per cubic yard was, accordingly, $0.6294. The cost of the dry excavation in the central division from May 4 1904, to June 30, 1911, was $66,992,606.52. The total amount excavated in the same period was 77,338,235 cubic yards. The central division consists of the high-level section of the canal, exclusive of the special constructions at the termini.

A HIGH-LEVEL CANAL

The excavation will cease in all probability when the level of 40 feet above the sea throughout the high section has been reached. If the plan were to construct a canal which should be a strait connecting the two oceans then the excavation would have to be carried down 85 feet or more further in order to provide a depth of 45 feet in the waterway. This would greatly increase the amount of excavation. The execution of this plan would involve much more than excavating a prism 32 miles long, 300 feet wide and 85 feet deep. The sides of the canal could not be maintained as perpendicular walls. The additional amount of material that would have to be removed from the sides in Culebra Cut in order to provide a width of 300 feet at a level 85 feet lower down would be nothing short of enormous. The angle of deviation from the perpendicular necessary at the bottom would have to be maintained, or more than maintained, clear up to the general surface. There might be exceptional locations where some departure would be allowable, but we have here the general rule. Now this is scarcely a prohibitive consideration. It is a mighty debit. But there would be a mighty credit. No locks would be



WORK ON THE CULEBRA CUT. AT THIS POINT, CUCARACHA, SOME OF THE MOST SERIOUS LANDSLIDES HAVE TAKEN PLACE

required. If this were the whole story one might think that a sea-level canal would have been at least a reasonable solution of the problem of providing water communication between the Atlantic and Pacific. The elimination of the locks is an attractive idea. However, there is another large consideration which must be taken into account. This is the problem involved in the existence of the Chagres River watershed.

This basin has an area of about 1,320 square miles above Gatun. The canal follows its valley through the greater portion of the high-level section. It repeatedly cuts across the river itself. There is an average annual discharge of about 7,415 cubic feet per second. The fluctuations from year to year are very considerable. In 1905 the average discharge for the year fell to 4,582 cubic feet per second; in 1893 it was as high as 11,471 cubic feet per second. November is the month of greatest discharge, and March the month of minimum discharge. Maximum and minimum figures for the months, as found from observations covering twenty years, are 14,082 and 1,555 cubic feet per second, respectively. A consideration of the foregoing facts prepares us to understand that the Chagres River is subject to great changes in respect to the amount of water in its bed. It is, in fact, a torrential river. In December, 1906; January, 1909, and June, 1909, occurred three great freshets. At Gamboa, which is in the vicinity of the northern end of Culebra Cut, the river rose about 31 feet in the space of twenty-four hours. The sudden rise in the case of each of the other freshets was considerable, although less than this in amount. A simple ditch running from ocean to ocean would be subjected, accordingly, to tremendous changes in the amount of water flowing into it from the Chagres valley. Provision would have to be made to deal, not merely with the normal average flow of water, but with enormous and sudden increases. The Chagres River is a great fact. It would be out of the question to expect the canal channel to receive the whole of its waters. The problem that must be solved, whether the sea-level or a lock canal be constructed, is how to control the waters of this river. The present solution involves two factors; one of them is the high-level channel, the other is the creation of a very large body of water in the path of that channel. This large body of water is the future Gatun Lake. It is being brought into existence by the construction of the great Gatun dam. As already noted, its surface will have an area of 164 square miles. A little consideration will convince one that we have here a highly efficient means of dealing with sudden and large influxes of water without any especial change in conditions. The only change that would have significance is that of the level of the lake. But this could not become large in a short time. Consider a moment. A layer of water 1 foot deep over an area of 164 square miles would have a volume of 4,572,000,000 cubic feet. An inflow at the rate of 10,000 cubic feet per second would, accordingly, require 457,200 seconds to cause a rise of 1 foot over the surface of the lake. That is to say, this small change in level would not take place under five days' time. Furthermore, there is the large spillway by which the height of the lake can be controlled. Of course, the dam, spillway and locks at Gatun, and the locks, dam and spillway at Pedro Miguel and Minaflores will have to sustain the hydrostatic heads behind them. A large break at Gatun dam would be a catastrophe. But what other method of controlling the Chagres would not involve a risk of the same general kind? The Government engineers seem to be studying every possibility and providing for every conceivable emergency. Gatun dam has been given an enormous width of base; two spillways are being constructed—one at Gatun and

VIEW AT BAS OBISPO, LOOKING SOUTH. THE BERM ON THE LEFT IS PERMANENT. THE ROUTE OF THE RELOCATED PANAMA RAILROAD IS SHOWN

one at Minaflores; emergency dams are to be located upon locks.

CONSTRUCTIONAL STATISTICS

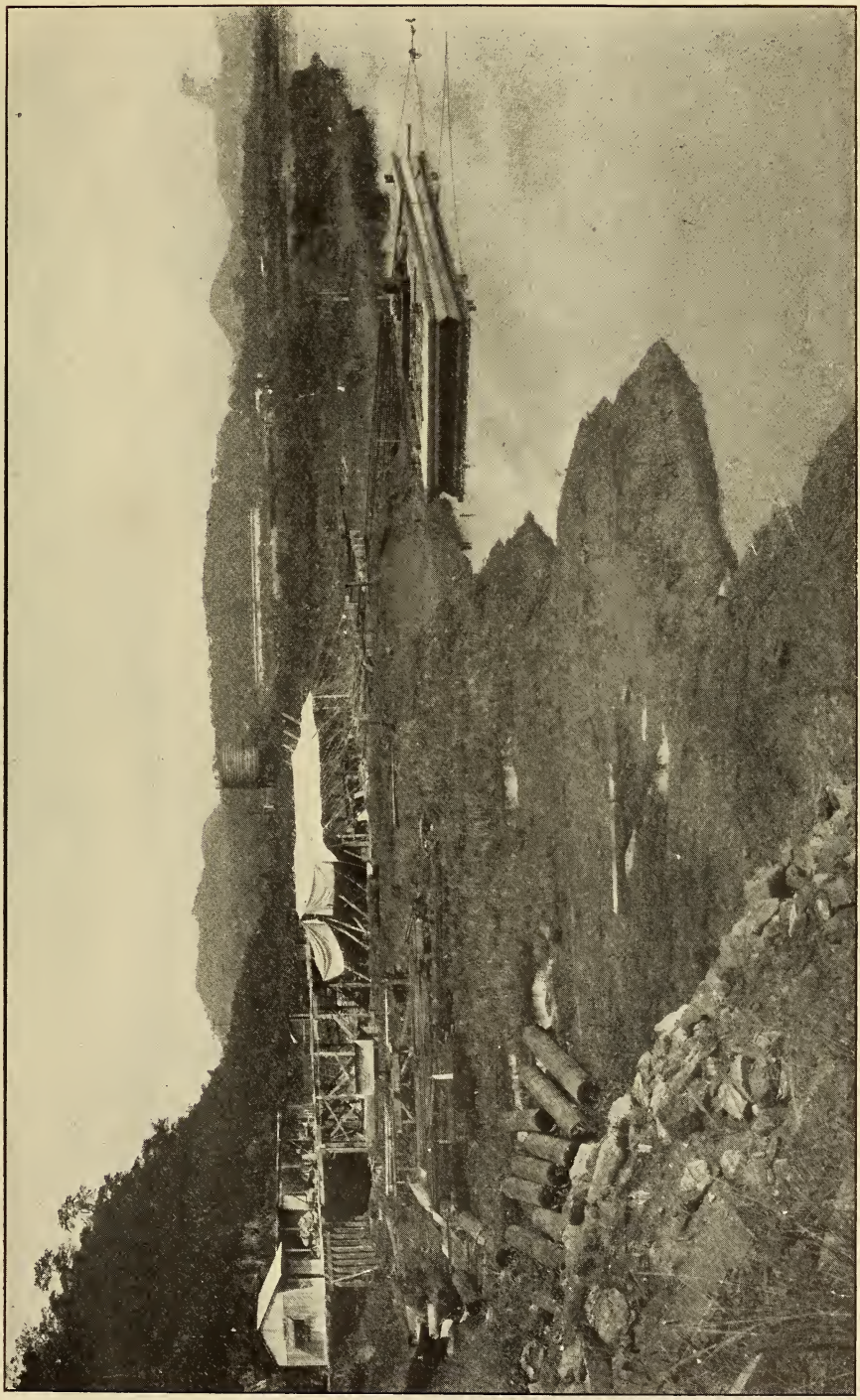
Although the present plan does not require for its execution nearly as much excavation as the sea-level plan would involve, it does, nevertheless, call for the removal of enormous volumes of rock and earth. We have already considered the dry excavation required at Culebra Cut. This one section includes the great bulk of this class of work. However, the construction of the canal channel involves much wet excavation. On the Atlantic and Pacific sides the channel has its bottom below sea-level up to the lowermost lock. These channels must, of course, be run out from the shore until deep water is reached. We have thus a very great amount of under-water excavation. Accordingly, the dredge has been a notable piece of apparatus on the canal, second only, it would seem, to the steam shovel.

The wet excavation on the Atlantic end of the canal had amounted at the end of the fiscal year in 1911 to 23,972,128 cubic yards. This work cost $5,647,574.78, or an average of $0.2356 per cubic yard. On the Pacific side the wet excavation had amounted on the same date to 28,586,972 cubic yards, costing $7,046,255.17. The average cost here per cubic yard was $0.2465. In neither of these cases has hydraulic excavation been included. On the Atlantic end the cost per cubic yard for the three months at the end of the fiscal year was pretty close to the average for the whole period since dredging began. It was $0.2413. But on the Pacific end this wet excavation was for the same three months done at a much less figure than the average for the whole time. The cost was only $0.1825 per cubic yard.

There has been also an amount of hydraulic excavation. On the Atlantic end this amounted by the end of the fiscal year 1910-11 to 28,605 cubic yards, at an average cost of $0.3099 per cubic yard. On the other end of the canal a much larger amount has been done up to the same date. That is to say, 197,677 cubic yards had been excavated. The average cost per cubic yard was $0.6566, or more than double the expense per cubic yard on the Atlantic side. At the Miraflores locks 332,703 cubic yards of hydraulic excavation had been done up to the end of the fiscal year at an average expense of $0.5870 per cubic yard.

BUILDING WORK

The canal is involving the construction of dams, spillways, locks, etc. In consequence, a great deal of concrete will be required. It is estimated that the amount will be upwards of 5,000,000 cubic yards. The Portland cement is imported from other than local points, but the sand and rock are produced in the immediate vicinity. Thus, at Porto Bello, on the Atlantic side, a large battery of crushers is at work breaking up rock. It may be interesting and useful to learn some of the costs. Let me confine them to the quarter ending June 30, 1911. At Porto Bello the expense of stripping, drilling, blasting, loading, transportation, tracks, power, maintenance and equipment and an arbitrary charge on the plant all amounted to an average of $0.8407 per cubic yard. The expense of crushing was an average of $0.3735 per cubic yard. The towing of this crushed stone to the vicinity of the storage point amounted to an average of $0.4923. The unloading from the barges amounted to an average of $0.435 per cubic yard. The expense for transportation by rail from the barges to the place of storage cost, on the average, $0.1829 per cubic yard. If to these items we add the division expense of $0.0307 per cubic yard, we have a grand average of $2.36 per cubic yard as the cost of the stone by the time it is actually in storage. The stone being produced at Ancon quarry cost, however, very much less



REINFORCED CONCRETE BARGES ON PANAMA CANAL

by the time it reached storage. Thus, for the same quarter the quarrying, the crushing, the rail transportation and division expense, which were all the items, were, severally, $0.5221, $0.1415, $0.1136 and $0.0184 per cubic yard. These gave a total of $0.7956 per cubic yard for the stone when in storage. It will be noticed that in this case a cubic yard when in storage has cost only a little more than one-third what in the other case the same amount cost when in storage. This is to be explained in part by the fact that the stone produced at Porto Bello had to be towed and unloaded from the barges, while these expenses were not incurred in connection with the product of Ancon quarry. In this way we may account for $0.9280 per cubic yard. At Ancon quarry the stripping, drilling and blasting all cost more than at Porto Bello. On the other hand, the power expense was $0.0542 more at the latter quarry than at the former. As to the operation of the crushers, there is a difference in favour of the Ancon stone of $0.0133 per cubic yard. This difference is about 46 per cent. of the larger cost; that is to say, the operation of crushing at Ancon quarry can be performed at a little over half the expense as the same operation at Porto Bello. Of course, there may be a difference in the rock itself sufficient to account for certain of the cost differences.

SANITATION AND LABOUR

The number of persons required on such a gigantic construction as that of the Panama Canal is very great. During the fiscal year 1908-1909 the average number of employees was 44,261. Of that, 12,299 were white and 31,962 were negroes. The presence of 44,000 employees actively engaged in the management, construction work or accessory duties involves the presence of many other persons not employees. These persons are largely the women and children of the families of those engaged upon active duties. The Isthmian Canal Commission controls, not merely the canal itself, but a strip of country extending across the Isthmus and including within it the site of the waterway. This strip—the canal zone—is about 10 miles wide. Its central line, or axis, follows with more or less exactness the route of the canal. Within the canal zone are two cities, Panama and Colon. The entire population, including employees and other inhabitants, amounted to 127,362. The total of deaths from all causes was 2,807. This is a mortality rate of 22.04 per 1,000. The preceding year the rate was 27.67 per 1,000. If we take only employees into account, we find that the deaths were 530 in number. This gives a death rate of 11.97 per 1,000. For the preceding year the rate was 18.32. We should expect a smaller death rate amongst the employees than amongst the whole population, especially for the reason that the employees are presumably selected persons. Thus, men going from the United States would be men in good health and in the prime of life. On the other hand, the change of climate and the arduousness of the duties would tend to reduce this advantage. However, it is not only disease that is at work. Many die from railway accidents and other violent causes. Thus, of the 530 employees who died, 178 died violent deaths. As to diseases, the principal ones were pneumonia, nephritis, pulmonary tuberculosis and various fevers. Of these, pneumonia claimed the largest number (60) of victims. Nephritis was next (54); then followed malarial fever (47) and pulmonary tuberculosis (38). The employees came from everywhere. Nearly one-third of the deaths of employees was amongst those coming from Barbados. Jamaica comes next with about one-sixth. These two sections furnished 48 per cent. of the employees who died. Of the white Americans employed, death claimed but 45. These facts lead us

to expect that climatic change is not so important a factor. In further illustration of this may be cited the low death rate for white American employees and their families. There were 8,105 such persons. The total number of deaths was 64, which gives a mortality rate of 7.89 per 1,000.

The figures for the fiscal year ending June 30, 1910, are even better yet. Thus, the number of white American employees, together with their families, etc., amounted to 9,198. And yet the number of deaths was less—54. The rate corresponding is 5.87 per thousand. It is not entirely clear whether this number—9,198—is restricted to whites. If it includes negroes as well, then the reduction in the mortality rate is even better. The entire number of employees was 50,535; the number of deaths 548. That is to say, although 6,274 more people were employed, only 18 more died. The death rate was, in fact, 10.84 per thousand for the whole number. As compared with the rate for 1907-1908, the rate showed a decrease of nearly 41 per cent. If we note the improvement as regards white employees, we find a reduction of just a little more than 41 per cent. As to negroes, the reduction was something over 36 per cent. That is to say, the improvement was great for both whites and blacks, but was greater for the whites. The death rate for white employees 1909-1910 was 9.03 per 1,000; for negroes, 11.40 per 1,000. The population of the canal zone as a whole increased to 144,614. The death rate was 18.91 per 1,000. The betterment, as compared with 1907-1908, was nearly 32 per cent. It is interesting to note that in 1908-1909 six nonogenarians died, and in 1909-1910 one. In each year a centenarian died. These facts show that a good old age is no uncommon thing. The number of violent deaths amongst employees was 173—a smaller number than the year before. Of the diseases claiming victims, pneumonia easily led, with 77; pulmonary tuberculosis, with 51, came next; malarial fever followed, with 45, and nephritis was fourth, with 40. The deaths from pneumonia increased in actual number, as did also the mortality rate for this disease. The same may be said with reference to pulmonary tuberculosis. It would seem as if the year 1909-1910 was a very trying one with respect to the lungs. The Barbados and Jamaica still led as the districts furnishing the greatest number of employees who died. They furnished, in fact, 51 per cent. The white employees from the United States numbered 5,573. Of these, only 31 died, giving a very low death rate—5.56 per 1,000.

For the three fiscal years included between 1907 and 1910 the number of white employees remained almost stationary, averaging 12,104. Less than one-half of these came from the United States, the average number being, in fact, 5,245. The number of white Americans also remained more or less stationary. There were very many more colored employees than white ones. The percentages for 1909-1910 were, respectively, 76 and 24. The respective numbers of deaths are not at all proportional to these, being 440 and 108. The corresponding percentages are 80 and 20. That is to say, a distinctly larger percentage of colored people die than of white. Now, the whites do not die in as great numbers comparatively; but a greater percentage of them are reported sick. Thus, in the year 1909-1910 there were always 36.47 white employees per 1,000 in hospital to 13.49 colored. If we include those who were sick in sick camps and in quarters, the numbers per 1,000 are, respectively, 45.18 and 16.14. The foregoing facts seem to imply that there is a greater percentage of recoveries amongst the whites. This may be occasioned by a stronger tendency amongst them to resort to the hospital whenever ill. As far as

climate is concerned, one would expect the advantage to be with the blacks, especially as so many of them come from sub-tropical districts.

The great improvement in health conditions that has gone on in the canal zone is undoubtedly, humanly speaking, to be attributed to the methods of the Department of Sanitation. Apparently there is no yellow fever. The sick do not eat a great deal, as may be judged from the fact that 26 cents is the subsistence expense per day. Medical attention costs four and one-half times as much.

The police control of the canal zone is a matter of importance, and constitutes one element of the enterprise. During the fiscal year 1909-1910 there were arrested a total of 6,947 persons. From this we might suppose that of every 7 or 8 persons employed on the canal and remaining a year 1 gets arrested. But this total of arrests no doubt includes many non-employees. It does not include, however, the cities of Panama and Colon. Grand larceny appears to be the favorite charge. Of those arrested, 3,866 were labourers. Apparently the servant problem is troublesome along the canal, as about 5.7 per cent. of the persons arrested are classed as "domestics." Three ministers, 1 missionary, 1 superintendent, 1 washerwoman, 50 tailors, 47 janitors, 1 attorney, 120 merchants, 2 physicians and 1 prize-fighter are some of the items.

Schools are maintained. The total enrollment, 1909-1910, was 2,688. Of the twelve grades in which instruction is available, the first nine included all but 11 pupils. The number of teachers employed averaged about 57. The average number of pupils under one teacher's care was, accordingly, about 47.

The Panama Railroad maintains regular service between Colon and Panama. The mileage of this road is 47.07. there are twenty intermediate stations between termini. Several are flag stations only. Every day except Sunday one may leave Colon at 5:20 A. M. and arrive at Panama at 7:40 A. M. This is an average rate of 20 miles per hour, including stops. This compares very well with the ordinary "accommodation" service in the United States. There are, including this one, three trains per day southward—two in the morning and one in the afternoon. There is an additional train on Saturday, leaving at 6 P. M. In the opposite direction there are four regular trains per day. On Sundays more trains run than on week days.

LAND IN THE CANAL ZONE

A portion of the canal zone is, of course, occupied by the canal. Another portion belongs to the Panama Railroad, and so to the United States. Another portion is held under private title. Altogether, this zone includes 436 square miles. Of this area, the Government has immediate or indirect title to 363 square miles. About one-half of this may be styled "vacant public lands." By a law passed February 29, 1909, the President of the United States is empowered to grant leases for periods not exceeding 25 years, and upon terms deemed suitable by him to bona-fide settlers. The maximum amount of land that may be leased under this law is 50 hectares.

NOTE.—We are indebted to the Atlas Portland Cement Company for the photographs from which the illustrations on pages 169, 171 and 173 have been made.

(To be continued.)

THE NEW BUSINESS CENTRE OF THE UNITED STATES

By A. E. Stilger

II.—OPPORTUNITIES FOR IMPROVEMENT

IT has already been pointed out that the tendency, the development of which has resulted in the remarkable increase of all kinds of business in the district in New York City of which Thirty-fourth street is the backbone, manifested itself several years before the Pennsylvania Railroad determined upon the location and construction of its terminal on Seventh avenue.

A pioneer in the movement was the great dry goods firm of R. H. Macy & Co., who had for many years occupied a store on Fourteenth street, formerly an active retail district, and who, in 1901, erected a thoroughly modern and well-equipped building of eight stories in height at the intersection of Thirty-fourth street, Broadway and Sixth avenue, and who have developed their business most successfully in the new location. This perception of the coming development of the district has been followed by other firms, and among these we may mention Messrs. James McCreery & Co., occupying a building of ten stories; Messrs. B. Altman & Co., whose establishment is seven stories in height; Messrs. Saks & Co., also of seven stories, and, among the most recent, the building of Messrs. Gimbel Brothers, which is ten stories in height.

It is intended, in this article, to consider principally what might yet be done toward perfecting the development of a section in which such abundant opportunities are awaiting action.

When it was first made known that the Pennsylvania Railroad Company had determined to construct its new terminal in this district, involving the expenditure of more than fifty million dollars, and presumably resulting in the direction of a great amount of traffic to the neighbourhood, speculation ran rife as to the influence upon the business of the locality. The small tradesman, business man and propertyowner anticipated a marvelous influx of trade and prosperity, together with an attendant increase in land values. These hopes have been realized, in a measure; but the full extent of the development is yet to be attained. The magic word of only two letters—"if"—stands in the way.

The great terminal of the Pennsylvania Railroad, with its vast enclosures, covers eight acres of ground, quarried out of the rock—800 hundred feet square in station capacity alone, and stated to cover more territory than any other building ever constructed at one time in the history of the world. This station, built in less than six years, is intended to afford every facility for access to the business centre of the metropolis from all parts of the country. If, with this point in view, the railroad company would offer special commutation and trip tickets, at minimum rates, for the especial purpose of inducing suburban residence, building up this class of traffic and drawing vast numbers of passengers into the neighbourhood from Long Island and New Jersey, a tremendous impetus would be given to trade in this section. Facilities create traffic; and if proper inducements were offered there would result an unequaled concentration of interests in a business district in which there already exists every op-

FIFTH AVENUE AND THIRTY-FOURTH STREET IN 1899.

The store of B. Altman & Co. now stands on the right-hand corner.

THE DEPARTMENT STORE OF B. ALTMAN & CO.

On the corner of Fifth avenue and Thirty-fourth street. Former site shown above.

UNIMPROVED PROPERTY OPPOSITE THE PENNSYLVANIA RAILROAD STATION IN NEW YORK

PROPERTY AWAITING DEVELOPMENT OPPOSITE THE PENNSYLVANIA STATION IN NEW YORK

The Gimbel store is on the right.

THE DEPARTMENT STORE OF R. H. MACY & CO., BROADWAY AND THIRTY-FOURTH STREET, NEW YORK
The small shop in the foreground was recently sold for $1,000,000; the most valuable plot in New York.

portunity that can be desired in banking, business, trade of all kinds, amusements, and general attractions. Again, the valuable land adjoining and surrounding the terminal, with its imposing architectural effects, should be utilized and beautified, both with respect to its own increased value and the consequent advance in land values in the immediate neighbourhood.

It is announced that the New York Central Railroad contemplates, in connection with its improvements, a magnificent hotel, together with other attractions, to retain the stream of humanity which pours through its gates. The Pennsylvania Railroad should vie with this example in offering attractions to the wayfarer, and, not content with providing simply a great terminal building from which the traveler will depart immediately upon arrival, place before him all that is necessary to retain him in the vicinity. Such an example would be followed by the various propertyowners, and if these would improve the surroundings of the great buildings which extend from block to block and render Thirty-third and Thirty-fifth streets a part of the district second only to the main thoroughfare in business importance—if these propertyowners, seeing the advantages offered for the centralization of trade, would improve the adjoining streets in every way, the demand for business places would be kept up and the continual increase of population caught and retained in the locality where convenience and opportunities converge. Such a cooperation of all concerned would result in retaining for an indefinite period the "busy hum of men" in this portion of the great city.

The extent to which it is the power of those already interested to develop and increase the value of the district appears in the fact that one small bit of this favoured land has, as already stated, changed hands recently for a consideration of a million dollars, this being at the very highest rate per square foot which has been attained in any part of Manhattan. This price was paid because this

BROADWAY AND THIRTY-THIRD STREET. THE GIMBEL AND SAKS STORES AND THE BUSY STREETS

precious area stood at the spot where the King and Queen of New York streets — Broadway and Thirty-fourth streets—meet and embrace. Such great values, however, may be created in this entire district, from river to river, simply by the provision of proper facilities and by close attention to the important things which attract business. This favoured district may thus be made, to propertyowners and shrewd business investors, to surpass, as it already approaches, any gold-mining district in the world. Already the traffic statistics inform us that while, during the past year, even Forty-second street has shown a falling off in numbers of two hundred and seven thousand, there has been shown at Thirty-fourth street the greatest traffic increase of any one year.

The wealth of the world has increased more rapidly in the last century than ever before, and during the past decade it has made its greatest increase, and probably the gain has been greater in this portion of New York than in any other one part of the country. To share in this advance, it is the part of wisdom to select this progressive locality for the development of undertakings, old and new, and to join in its advance, not only in the commercial side, but in the financial side also, using the local banking institutions and working in harmony with the opportunities which are thus offered for further development.

Reference has already been made to the new general post office building, which is rapidly approaching completion, adjoining the great railroad terminal. If, as appears probable, the old post office building is removed from the City Hall Park, it will follow that the entire postal equipment will be transferred to the new building. This change will bring into the new business centre a large portion of the activities which are now gathered about the old post office, and which must find it necessary to be near the new postal headquarters, and this in itself will add to the business importance of the neighbourhood.

(To be continued.)

A MODEL MANUFACTURING ESTABLISHMENT

THE NEW PLANT OF THE BEST MANUFACTURING COMPANY

(Concluded from the January issue.)

THE location and dimensions of the machine shop are shown in the plan, the part north of the dotted line being used for machining operations and that to the south for pipe bending and peening. Material comes in from the foundry and is deposited in the storage space for castings, either in the middle bay or in the northwest corner. Flanges travel along the north end of the shop, first to the boring and tapping machines, then to the facing lathes, then to the drill presses and on to stock. Large fittings and valves and special castings are taken care of on the boring mills, planers and lathes. Small valve bodies are machined on turret lathes next to the boring mills.

Smaller parts and fittings are taken care of on the lathes on the east side of the shop. All valves are assembled on the fitting floor in the northeast corner. From here they are taken to the testing press and then go to storage, the larger valves on the stock space on the floor and the smaller ones in the stock bins in the gallery.

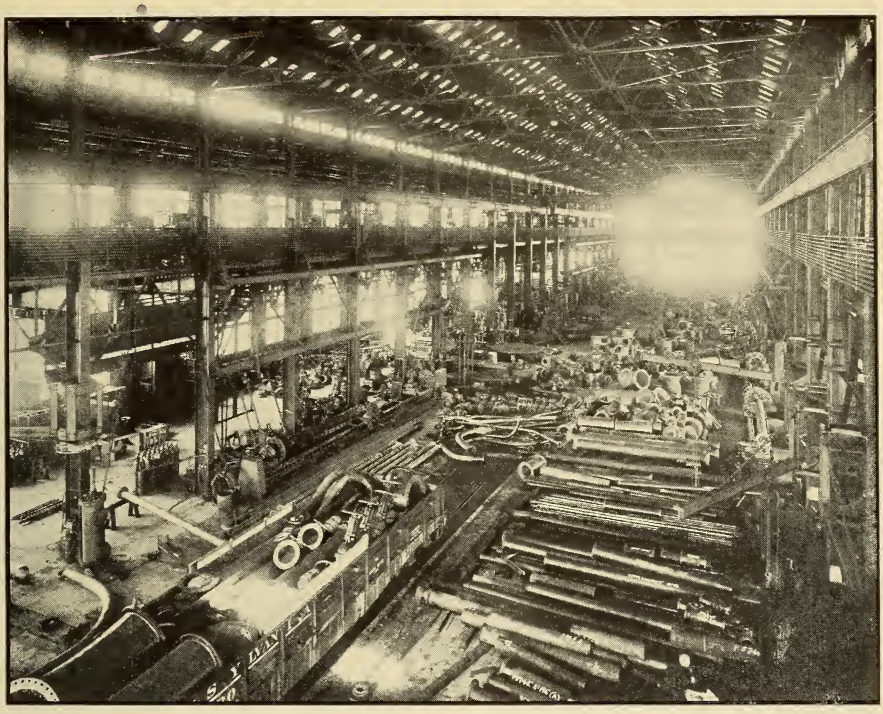
Electric driving is used throughout, the larger tools having individual motors and the smaller ones being driven in groups from counter-shafting.

The main shafts and the counter-shafting are supported from the steel columns, so as to be clear in the main bay and to permit of belting to both main and side bays easily. Some of the tools in the equipment are a large open-side planer, a vertical and a horizontal boring mill, a bank of smaller boring mills, turret lathes and ordinary lathes, large and small tapping machines, double-head facing lathes, multiple-spindle drills, single drills, a gang of pipe-threading machines and other special tools.

The lathes are of various makes, some from the New Haven Manufacturing Company, of New Haven, Conn.; some from the Pond Machine Tool Works, of Plainfield, N. J., and some from the R. K. Le Blond Machine Company. Small boring mills are of the make of the Betts Machine Company, of Wilmington, Del., multi-spindle drills from Manning, Maxwell & Moore, tapping machines from Baker Bros., drill presses from the Niles-Bement-Pond Company Works in Philadelphia, and from the works of Prentice Bros. Company, Worcester, Mass., and radial drills from the Prentice Bros., and from the Niles-Bement-Pond Works at Ridgway, Pa. The big boring mills and the planer are from the Niles Tool Works of Hamilton, Ohio, and the open-side planer from the Detrick & Harvey Company of Baltimore.

Particularly interesting are the jib cranes, supplied with a 2-ton electric hoist, made by the Shepard Electric Crane & Hoist Company, one of these cranes being supplied to serve each of the larger tools, and one for two or more of the smaller tools. A 3-ton girder crane also runs over the assembling and small lathe department in the north end of the east bay. The main bay is served by a 5-ton, a 10-ton and a 15-ton Morgan electric overhead traveling crane. The pipe shop has a 15-ton crane of the same make and description.

Far overhead, above the cranes, is placed a row of flaming arcs,



LOOKING NORTH DOWN THE MACHINE SHOP

which, with their intense light, give general illumination for the main bay, while at each individual tool is an incandescent on a flexible cord and a support of pipe or iron rod which can be moved to bring the light to any position desired, or the lamp can easily be taken off and held by hand for closer inspection. It makes a system at once simple and effective.

Hydraulic pressure for testing purposes is obtained up to 800 pounds per square inch from the lines serving the elevators, and up to 1,500 pounds from a Gould's triplex pump provided especially for the purpose. Pressures up to 10,000 pounds are obtained by means of hand pumps of special design.

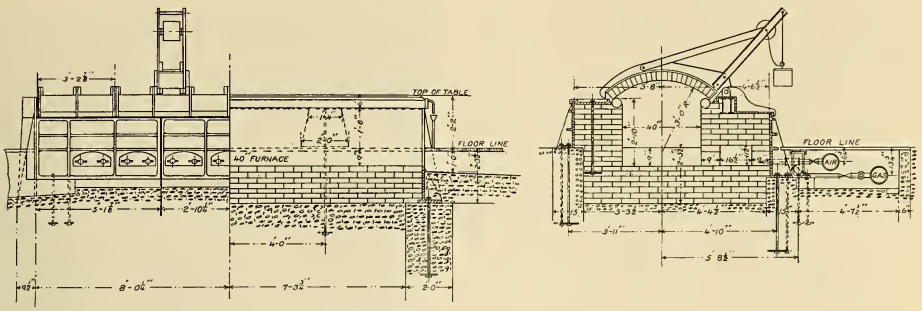
In the pipe shop at the south end of the building are carried on the operations of making pipe bends, attaching flanges to pipe by the Van Stone and the shrinking and peening processes, and welding steel nozzles on pipe for headers.

Pipe for bends is filled with sand by gravity from an overhead hopper. The ends are then plugged, the pipe placed in the furnace, and that portion which is to be bent heated to the proper temperature. The pipe is then placed on the bending table, where, by means of an electric winch, it is bent around appropriately placed pins and forms to give the exact curve and angle required. The purpose of the sand filling is to prevent the pipe from buckling while being bent, and after the bend is made the sand is emptied into a tank below floor level, from where it is blown upwards to the gravity hopper.

Nearby is located a smaller furnace, where the ends of pipes are heated for Van Stoning. When heated to the proper temperature, the pipe is clamped in a machine and the end rolled over at a right angle to the center line. After the other end is put through the same

CONSTRUCTION VIEW IN MACHINE SHOP. BEST MANUFACTURING COMPANY, PITTSBURG

VIEW IN FOUNDRY UNDER CONSTRUCTION

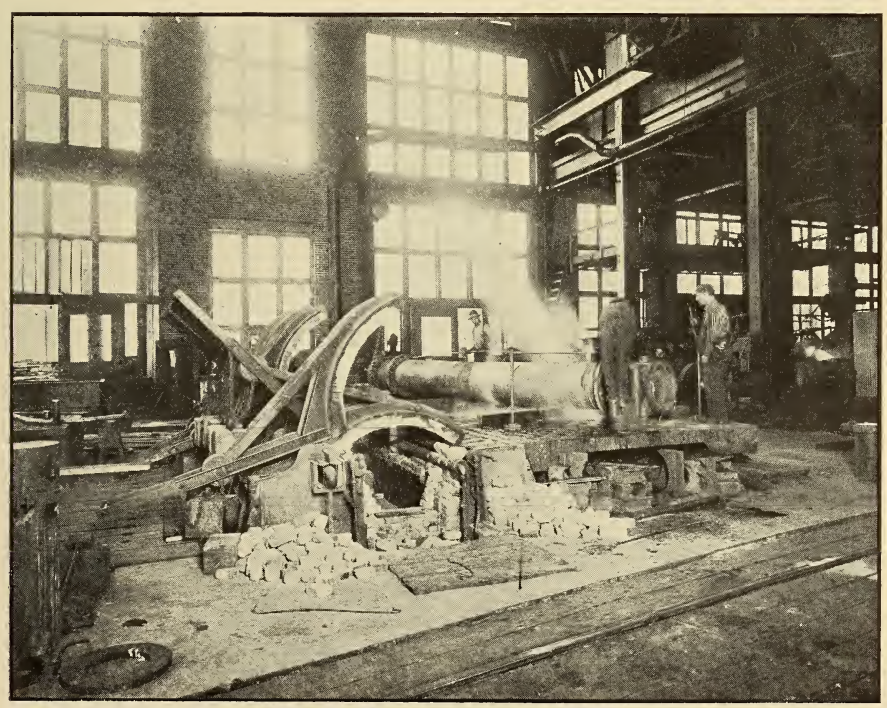


PIAN AND SECTION OF BENDING FURNACES

process of heating and rolling, the pipe is swung in a double-head lathe and the roll-over or lap faced at exactly 90 degrees to pipe.

Near the Van Stone machine is the welding department, which is principally occupied in attaching steel nozzles to pipe. The hole for the nozzle is cut out by the welding flame, and the nozzle deftly fitted to conform to surface of the pipe. The flame is then applied to the joint between the nozzle and the pipe, the resulting weld being as smooth and as complete as any made at a blacksmith's forge.

The lathe used in facing the Van Stone laps is 48 feet between heads, so that it would be possible to face the flanges on a pipe or header of that length. As pipe may now be obtained in lengths of about 40 feet in sizes up to and including 12 inches, a further elimination of joints is possible.

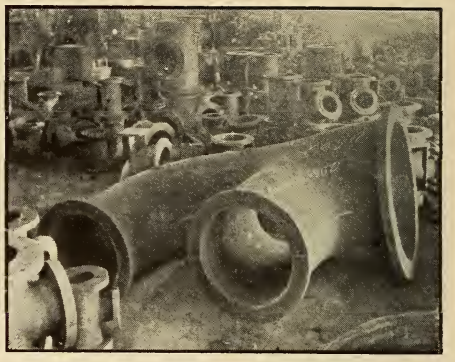


PIPE BENDING IN PROCESS

For the regular fittings, solid wooden patterns are used, pine being the material for special fittings, and mahogany for the standard patterns up to 10 inches in diameter; the flanges being bound with brass, and the facing plates having iron rims. Also for the standard patterns iron core boxes are used, and for sizes from ½ inch up to 2½ inches, for unions and other similar castings, metal patterns are made and generally used in gangs.

The pattern shop extends across the north end of the gallery and along the two sides about half the length of the shop. On each of the side galleries the machinery is installed in duplicate, so that the workmen do not have to go far from any bench position that they may have to get to a tool that may be needed, for sawing, planing or other operation.

In the east gallery there is also a dry kiln for seasoning the lumber by the carload after it has had a session in the out-door seasoning shed.



A BIG PIPE CASTING AFTER CLEANING

Band saws, furnished by the Atlantic Works, Inc., of Philadelphia, a Watkins woodworker (an imported machine able to cut out patterns of almost any shape), and a full equipment of woodworking machinery, furnished by the Oliver Machine Company, form the working installation of the pattern shop. It includes lathes, trimmers, join-

TOOL ROOM WITH STORAGE COMPARTMENTS

ers, combination rip and cutting-off saws, surfacers, sanders and special tools. A convenient outfit for the pattern shop is the Universal grinder made by the Mummert, Wolf & Dixon Company of Hanover, Pa. This grinds with coarse and fine emery, and is able to put an edge on circular or flat tools, either exterior or interior. The larger tools are driven by individual motors, and the smaller ones tools are kept in labeled compartments, as shown in the view of the tool room. The equipment consists principally of the following: Two-speed drills made by the Niles-Bement-Pond Company, Warner & Swasey lathes, Brown & Sharpe grinder and shaper, two Hendey Machine Company lathes, two lathes from R. K. Le Blond Machine Tool Company of Cincinnati, a couple of Prentice Bros. drills

ATHLETIC FIELD AND REST HOUSE. BEST MANUFACTURING COMPANY, PITTSBURG

by the grouping system from a counter-shaft.

Lighting is here accomplished by the use of Nernst lamps hung overhead, giving sufficient illumination without special lamps for benches or tools.

Beyond the dry kiln in the gallery is storage for finished parts and small fittings, which are taken care of in racks and piles until needed.

In the west gallery is located the tool room, where tools are made, repaired and stored. The from Worcester, milling machines made by the Le Blond Company and Cincinnati Milling Machine Company, shapers made by the Niles-Bement-Pond Company and Gould & Eberhart, a radial drill from the Foster & Holloway Machine Tool Company of Cincinnati, and a hollow centre lathe made by the Acme Machinery Company. All are arranged with plenty of working space around them, and are provided with overhead lighting by the lamps, but as the daylight is ample there is little need

for artificial lighting except during the dark hours and on very cloudy days.

South of the tool room is found the brass-working department, devoted to the machining of unions, small valves, and of brass parts entering into the construction of the large iron and steel valves.

The equipment of this department consists largely of turret lathes made by the Warner & Swasey Company, the American Tool & Machine Company and Lodge & Shipley.

An interesting process is the making of brass seat rings for gate valves from a single brass tube by a continuous process in which the tube revolves without stopping, while, by means of turret head tools and cutters, the seat rings are turned, threaded, and cut off as fast as the cutting speed of brass will permit.

Between the gallery and the main floor are mezzanine floors, located at each of four elevators and stairs, with toilet provisions of the most modern sanitary type and in sufficient number for all needs.

Besides special castings on order, the output of the Best Manufacturing Company's works is largely material for power plants. The special lines are: Standard, medium, extra heavy, and hydraulic gate valves of the company's own design; standard, medium, extra heavy and hydraulic fittings; special fittings of any design; pipe bends of any size or angle; large pipe fitted with special flanges, either Van Stone, peened or welded; special headers with nozzles welded on, the number, size and position of the nozzles being limited only by the area of the header surface to which they are to be attached.

The views of parts in process of construction of the shop and of finished material tell better than words the variety of the products turned out by this completely designed plant.

LOOKING DOWN LAKE GEORGE FROM THE FORT WILLIAM HENRY HOTEL ON THE LINE OF THE DELAWARE & HUDSON RAILROAD COMPANY

HOW RAILROADS AID INDUSTRIAL DEVELOPMENT

By Francis Washburn Hoadley

IN view of the fact that the primary reason for and object of all railroads is the transportation of freight and passengers, the other important work they have done in the past, are doing at present and will always continue to do, is often lost sight of.

As Mr. Morrill W. Gains said in his valuable article in the *Yale Review*, "In our material development railroads always have been and always will be the prime force. They are the reclaimers of waste places, the builders of cities, the awakeners of opportunity; to our growth as a nation their growth is still essential."

In the early days of railroad building the very fact of railroads being built had immediate effect upon the development of the country through which it passed, and the utilization of vast unoccupied territory was due directly to them.

At the present day, however, the industrial development of the United States, due directly to the enterprise and effort of our railroad companies, though not spectacular, as in the past, when they were the forerunners of development in uninhabited or sparsely settled sections of the country, is fully as wonderful and important.

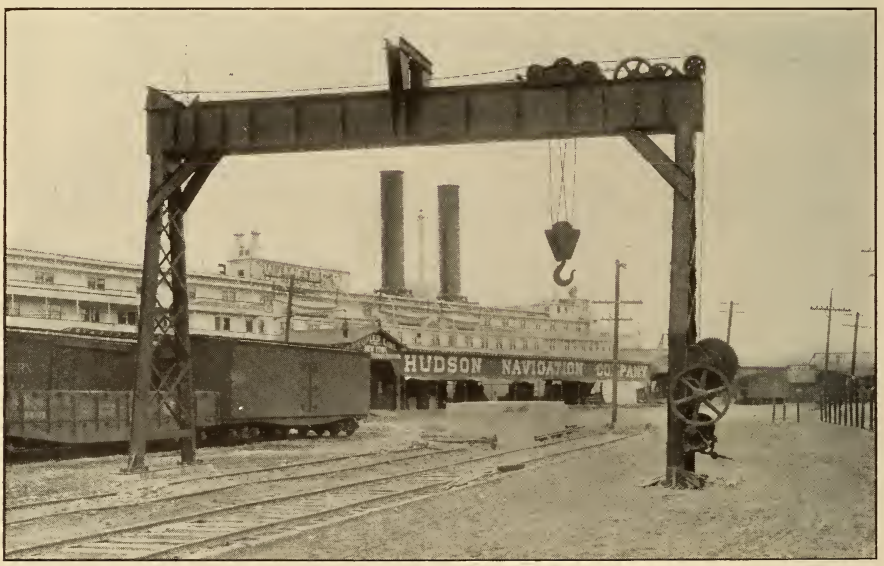
More and more all the railroad companies of America are giving their efforts to the betterment and upbuilding of the territory through which they pass, and one of the great factors in this work is the industrial department, which is proving of value and usefulness to all classes of our

citizens. The object in view of the industrial departments of the railroads of to-day is the utilization of the natural resources of the country, the education of the people along their lines in improved methods of doing things, and the directing of the attention of the public at large to opportunities for business openings and industrial enterprises.

A good illustration of recent industrial development work, not in a new section of the country, but in the midst of a portion of the United States which was among the earliest settled, is afforded by the industrial department of the Delaware & Hudson Railroad Company, of which Mr. Ira H. Shoemaker is the Industrial Agent.

The southern terminus of the Delaware & Hudson Company is Wilkesbarre, Pa.; the western, Binghamton, N. Y.; the eastern, Rutland, Vt., and the northern terminal is in Canada; and it is in this territory—no virgin one, as will be seen—that the energy of the industrial department of the said railroad is expended.

During the year 1911 eighty new industries located on the line of this road, forty-five of which were purely manufacturing, and fifty-seven additions were made to old industries. The establishment of these new industries and enlargement of older ones called for the expenditure of over $40,000 for the building of thirty-four new industrial sidetracks, and negotiations are now pending



MODERN ELECTRIC CRANE AT ALBANY, N. Y.

Built for the D. & H. Co. by the Industrial Works, Bay City, Mich.

The writer, though prepared by actual experience in railroad work in the West and South, where he had seen the effect of the railroads in unsettled territory, was surprised to find, on investigation, the vast influence the work of the industrial department of this railroad has had, and is having, on the territory which it covers.

with fifty-three other concerns for the installation of additional sidetracks. The estimated total tonnage to be derived from the developments taken care of by sidetracks built in 1911 is about 700,000 tons. In the development of sidetrack questions this railroad looks closely into the traffic worth and the operating features before deciding whether the

ONE OF THE LARGEST ANTHRACITE-BURNING LOCOMOTIVES EVER BUILT

Manufactured by the American Locomotive Co. at their Schenectady (N. Y.) Works.

railroad company would be warranted in cutting its main line and building the track, inasmuch as every side-track put in not only increases their cost of operation, but increases the risks of operation as well. The agreements for siding facilities, however, are uniform in their requirements in all cases so that there may be no discrimination.

The establishing by the Delaware & Hudson Railroad Company at Watervliet, just north of Albany, N. Y., of large locomotive and car repair shops, at a cost of about two million dollars, has had a marked effect in creating confidence on the part of many prospective enterprises locating in this district.

The operation of the industrial department of the Delaware & Hudson Company is well thought out and planned, so as to give the greatest possible efficiency and widest scope.

The company, through this department, maintains membership in all Boards of Trade and similar organizations along its line—about forty in all—as well as a membership in a number of remote organizations. It conducts an extensive educational campaign by the publishing and distribution of a large number of pamphlets, among important and valuable ones being "The Road for Industries," "Industrial Openings," "Old Holland and New Holland," "Fertile Idle Acres," "Orchard Development," "Forestry," "The Dairy Herd," "Liming of Land," "Increase the Crop Per Acre," etc. These books are of a uniform and convenient size, all well printed, and contain information of much value, not only to persons living in its territory, but to those contemplating the establishment of new enterprises.

For example, in "Industrial Openings" is given a list of industrial and business openings as reported to them by reliable business men interested in the welfare of their respective communities.

The ramifications of the industrial

GASOLINE ELECTRIC CAR

Built by General Electric Company at Schenectady (N. Y.) Works.

department of this road are too varied to describe in full, but the following will give an idea of them and the vast influence they have upon the upbuilding of this territory.

The good roads movement is encouraged by furnishing "road homes" at its expense to farmers. The operation of a "farm train," instruction on increasing the crop per acre, including clearing the land, ditching, draining swamps, grading roads, sinking wells, the use of explosives for blasting rocks, stumps, etc., are other lines of its educational work—a work which is being developed more and more each year. It is the object of this industrial department to feel the pulse of the country generally and try and keep in touch with the best up-to-date methods, and then disseminate information as widely as possible to the various organizations in the cities and towns along its lines.

That this work has been very successful is indicated from the fact that, though the Delaware & Hudson Company used to be called a "coal road," because it carried more coal than any other kind of freight, today, while it carries more coal than ever, the proportion of coal compared with other kinds of freight is much less. In 1830 the anthracite coal tonnage moved from the Hudson Coal Company's mines formed about 78 per cent. of the total tonnage, while in 1911 the anthracite coal so handled formed about 23 per cent. of the total tonnage, leaving about 77 per cent. for miscellaneous freight derived directly and indirectly from industries, which shows the miscellaneous industrial growth along its lines.

That great faith is evidenced by the manufacturers in this district is indicated by the following facts:

The paper mills in this district have a total output of over half the paper made in New York State. Three wall-paper mills alone have an annual business of about 150,000 tons, while the well-known Albany Perforated Wrapping Paper Company alone shipped out in 1911 more than 900 carloads.

Two cement plants, employing 700 people, produced in the same year over one million and a half barrels of cement, representing about 53 per cent. of the Portland cement made in the State of New York.

There are 20,000 people employed in the shirt and collar industry in Troy alone, and there are sixty-five such industries in the district; and the largest cotton mill in the United States is located at Cohoes, N. Y.

Between Wilkesbarre and Carbondale, Pa., on its line are fifty silk mills, employing 15,000 people and consuming two million pounds of silk annually, representing about one-third of the silk consumption of the United States. The largest button factory in the world, the Scranton Button Company, makes one million gross of buttons a year.

In the development of this territory, the Delaware & Hudson's industrial department has played no small part, and will continue to further its future growth—a growth which is not only assured, but is expected to outrival what has already been accomplished by furnishing free and accurate information to all who desire it for the establishment of industrial plants for which its territory is well adapted, affording, as it does, so many desirable localities, with land at reasonable prices, cheap fuel and electric power, quick transportation—many locations affording both rail and water facilities—and freight rates on West-bound business in certain sections lower than from New York, Philadelphia or Baltimore.

It is by such means and the operation of such an organization as the management of this railroad maintains that the future development of this country is being accomplished, and it is by the practical application of the rule of "helping others to help themselves" that the wise management of a railway builds up, not only their own business, but that of the entire territory which it serves.

The development of new industries brings with it men who show themselves adapted to both the technical and the commercial side of the work, and in no department of engineering progress has this been more evident than in the automobile industry.

We publish in this number the portrait of Mr. John North Willys, to whose tireless energy and high degree of efficiency the Willys-Overland Company has reached its present state of successful activity.

The activities of Mr. Willys in the automobile business began with the selling of the Overland automobile, and his success in this department led to the assumption of the position of general manager, so that when the opportunity offered he was able to acquire the control of the company. In the furtherance of the development of the business of the concern he acquired the Pope-Toledo Works, left available after the death of Mr. Albert A. Pope, and thus he has built up one of the greatest and most efficient automobile-building manufactories in the United States.

The administration of this great establishment, in its manufacturing, financiering, and selling, shows that it is the combination of all these elements which go to make up the efficient whole, and while such is necessarily a collection of efficient units, it must always be under the control and guidance of such a man as Mr. Willys has shown himself to be—a thoroughly efficient commander-in-chief.

JOHN NORTH WILLYS

PRESIDENT, THE WILLYS-OVERLAND COMPANY

See reverse side.

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ENGINEERING ON THE GOLD COAST

By W. H. Barker

THE last two or three decades have seen great strides in the development of the West African colonies, particularly those of the Gold Coast, Southern and Northern Nigeria. Modern enterprise is endeavouring to wrest from this fever-stricken tropical belt the wealth that undoubtedly exists there. Many are the tales that could be told of the old slave days; tales of profitable bartering with the natives, of fortunes made, and, alas! of sad endings. Even now there are many old "Coasters" who remember with mingled feeling the days before the commencement of the present engineering works.

Within recent years the rush for gold has, in all parts of the world, taken precedence over other commercial undertakings, especially when the latter are fraught with dangers due to malaria and tropical diseases. It was long known that the natives obtained gold by washing the sand from the beds of the rivers; in fact, gold dust was an important article in the trade of the old sailing ships which visited the coast for two or three years at a time, exchanging Birmingham and Manchester goods for the productions of this part of Africa.

Systematic development is now taken in hand. The large volcanic areas of the Central and Western provinces and the southern part of Ashanti have been opened up by a railway from Seccondee through Tarquah, Dunkwa and Oboase to Coomassie. This has enabled machinery and appliances of the most modern type to be conveyed to the mines. The old methods of carrying machinery by canoes or by head loads proved more disastrous than profitable. The landing of heavy machinery from the steamers in surf boats was in itself a very risky business, but the danger of the surf has now been overcome to a certain extent by constructing a jetty under the lee of a natural breakwater of rocks. Seccondee is now one of the most important ports of the colony, and at the present time construction works are in progress with a view to providing the town with a suitable and satisfactory water supply.

Some 140 miles along the coast, the comparatively new port of Accra is rapidly developing. Some years ago the headquarters of the Government were removed from Cape Coast to Accra, the only—but sufficient—point in favour of the latter being its fairly healthy position. The rainfall of Accra varies from 20 to 30 inches per annum, while owing to the absence of forests the mosquito and tsetse fly cannot thrive. As in most West African towns, there is no proper water

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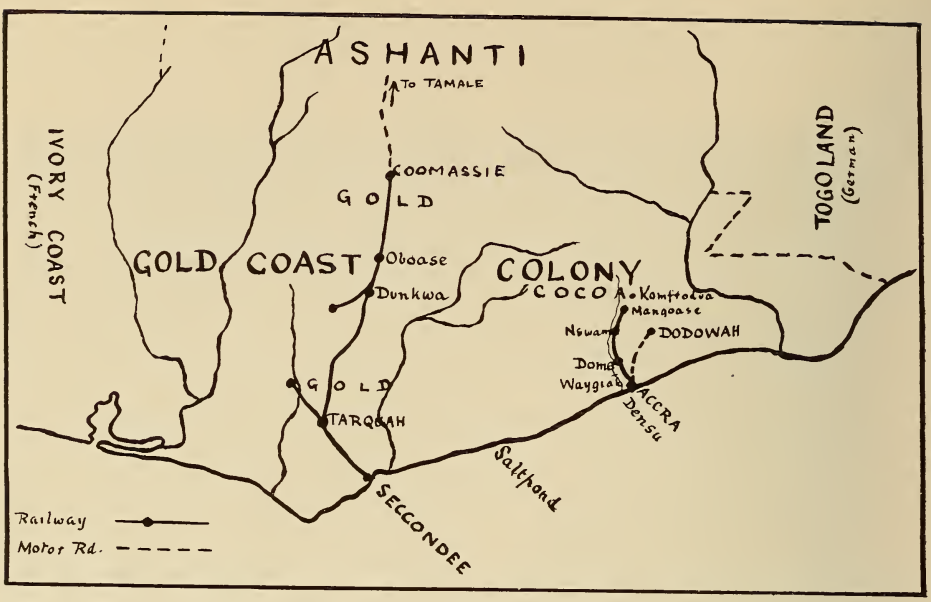


SKETCH MAP OF THE GOLD COAST COLONY

supply, the only source being rainwater, which, for Europeans, is stored in large tanks attached to their bungalows, while thousands of natives depend upon the natural drainage into ponds and pools. Furthermore, landing at Accra was the most difficult of all places on the coast. The surf was notorious, and the surf-boat passage from the steamer to the shore—often a distance of two miles—was most dangerous. Many a man has seen, with feelings of deep concern, the surf boat containing his baggage turn turtle in the breakers.

Away beyond the hills, some 30 miles to the north of Accra, the cocoa industry began to spring into prominence and the construction of a motor lorry road from Dodowah, at the foot of the hills, to Accra, deflected the trade to this point. Increasing in importance as a shipping port, it was necessary to minimize the dangers of the surf. It was, therefore, decided to construct a breakwater running out almost parallel to the shore-line. It was built of huge concrete blocks, and the work was almost completed when it was found that an extension was necessary on account of the silling produced by the "set" of the Guinea current at certain seasons. Even with the increased length the difficulty has not been obviated, and the work of pumping out the sand to a point some distance away is being carried on. Within the harbour thus formed, a jetty has been constructed for lighters which will be used when the harbour works are completed.

Connected with the harbour is the Accra-Akwapim Railway. This railway is for the purpose of "tapping" the cocoa districts beyond the Aburi hills. At first it was decided to construct the line as far as Nswam, a distance of approximately 30 miles, but as this does not penetrate far enough the line is being carried on to Mangoase. Perhaps, as the colony is opened up, the railway may be extended to effect a junction with the Seccondee-Coomassie railway, traversing the important cocoa, rubber and palm oil districts round Komfrodua and to the back of Saltpond. The line is almost completed, and will be taken over shortly by the Government. The past two years, however, have shown what will be a great source of trouble —the floods during the rainy season,

GENERAL VIEW OF THE PORT OF ACCRA, NIGERIA, SHOWING THE BREAKWATER AND JETTY, AND ANCHORAGE FOR SHIPS

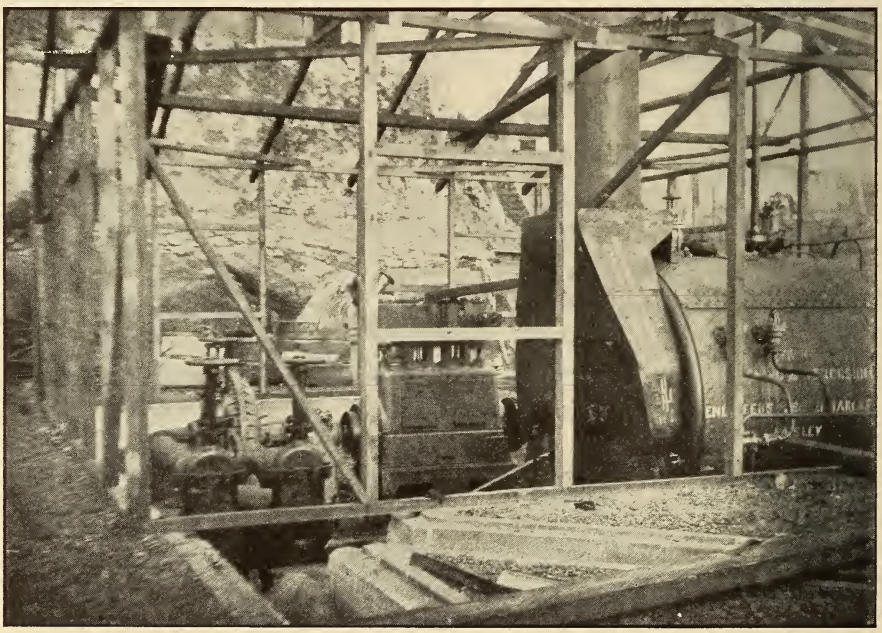
which have already done enormous damage to the bridges and permanent way.

The opening of the Accra-Akwapim Railway should mark a new era in the history of the colony. Essentially an agricultural country, the great drawback has been the lack of means of

YARD WHERE CONCRETE BLOCKS ARE MADE FOR BUILDING THE ACCRA BREAKWATER

VIEW ON THE JETTY AT ACCRA

conveying produce to the coast. Every season vast quantities spoil on the plantations for want of carriers. When it is considered that the greater



SAND PUMPS FOR CLEARING THE HARBOUR OF ACCRA

THE WATERWORKS LIGHT RAILWAY

TYPE OF ENGINE IN USE ON THE ACCRA-AKWAPIM RAILWAY

NSWAM, WITH THE FETISH PEAK "AKYEM BEPO" IN THE DISTANCE

part of the produce has to be carried by Hausas three to seven days' journey, or even longer, in head-loads of about 60 pounds, the state of the cocoa trade and the labour market generally will be easily understood. The great

SCENE AT ACCRA RAILWAY STATION

THE DENSU AT NSWAM

A dam constructed across this river near Oblogo will supply Accra with water

POSITION FOR ONE END OF THE DAM AT NSWAM

SIDE VIEW OF DOME RAILWAY STATION

need of the trader is roads, and the new railway will to some extent supply that need. The rolling stock is of a type suitable to the country and its requirements. The plates for the large covered vans for cocoa are sent out and are riveted and bolted together in the workshops there, while the passenger coaches, consisting of first, second and third class, are constructed on the principle of a long open carriage with a gangway down the middle.

With the harbour works and railway almost completed, the greatest engineering work at present in hand is the construction of a dam across the Densu at Waygiah. There are two great drawbacks to the present system of storing water. During the rainy season water lodges in various parts of the pipes and gutters, and so provides breeding places for the mosquito, while, if the dry season is prolonged, the natives suffer terribly from drought. Mortality is then very high, due largely to the contaminated water they are compelled to drink.

Like most rivers of the Gold Coast, the Densu varies from a rushing torrent in the wet season to a small rivulet which may or may not reach the sea in the dry season. Waygiah is about 12 miles from Accra, and just at this point the cliffs on either side of the river form a suitable place for the construction of a dam. In the actual work in the bed of the river the engineers are faced with two main difficulties; first, the uncertain element of the floods; and, second, the great depth of sand before striking the rock. It is hoped, however, that with the up-to-date electrical appliances which have been set up the work will progress smoothly and satisfactorily. It is understood that the reservoirs will be at such a height that it will be possible to supply the town by gravitation.

In a few years' time Accra will be one of the most flourishing and healthy towns on the whole of the West Coast. The present sanitation scheme will be completed, water and electricity will be laid on, landing will be more convenient and congenial, and means of communication with the interior will be established.

IS ELECTRIC TRACTION COMING FOR MAIN-LINE RAILWAYS?

A Discussion of Immediate Importance in Connection with the Transportation Problem

I.—THE OPERATION OF STEAM RAILROADS BY ELECTRIC MOTORS

By J. B. Whitehead

II.—THE ADVANTAGES OF STEAM OVER ELECTRICITY ON RAILROADS

By Arthur Curran

EDITORIAL INTRODUCTION

THE question of the substitution of electrical power for the steam locomotive upon main-line railways is both immediate and pressing. It is a question which has been actively discussed in technical and professional societies on both sides of the Atlantic, and it has gone beyond the academic stage and entered into the field of practical application to an extent which warrants the application of the data thus obtained to the solution of the general problem.

Like every subject in which large commercial and practical interests are involved, there are many apparent contradictions existing; and, in consequence, differences of opinion have appeared which have become even violent at times. The conservative railroad manager and engineer is apt to resent the intimation that anyone who has not grown up in the service of the railway is in any way qualified to suggest improvements in equipment and operation. The electrical engineer, flushed with the magnificent achievements which have marked the developments of his chosen field of applied science during the past quarter-century, believes thoroughly that the steam locomotive is doomed to the scrap heap, and that the introduction of electrification is delayed only by the stubbornness of the superintendent of motive power, who does not want to be convinced.

Out of all such opposing and contradictory views there has been growing a broader and more reasonable view of the subject, partly due to the wider familiarity which has been gained by the railroad man in the use of the electric locomotive in terminal service, partly to the practical experience in electrical work upon railroads by the electrical engineer, and still more due to the growing demands of the actual conditions of the transport problem in and about the great cities of all parts of the world. The present view of the situation is well expressed in the wise words of Mr. George Westinghouse, in the address which he delivered in July, 1910, before the joint meeting of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers in London.

Mr. Westinghouse said:

"The great difficulty in the electrification of standard railways is no longer the engineering problem of developing a locomotive and an electrical system which will operate trains, but it is a broad question of financial and general policy of far-reaching scope, considering the fu-

ture electrification of railways in general as distinguished from isolated cases of limited extent, and requiring a combination of the highest engineering and commercial skill."

Taking this broad view of the subject, it is now time to lay aside all personal and professional prejudices and consider the subject in the light of the actual conditions which are compelling intelligent action.

It must be apparent to the unbiassed observer that the transport of passengers, especially in the vicinity of great cities, is, at the present time, in a position which is the crude development of methods having their origin in a very different state of affairs. When steam railways were first introduced the service demanded was limited in volume, and generally employed only for distances greater than ordinary daily requirements. As cities extended their limits, and as changes in business methods demanded the daily travel of many individuals to and from their occupations, there grew up the frequent local trains from suburbs to the business centres, and the steam railway found itself practically compelled to meet conditions which were not altogether in the minds of the original projectors and operators. The great terminal station, usually combining the functions formerly provided by the inn from which the stage coach made its departures, with the opportunities for an imposing architectural structure, became congested with the ever-increasing multitudes of short-trip, regular, suburban passengers. The cumbrous system of ticket-sale, collection, and audit, entirely appropriate and suitable for the original service for which it was devised, has been overtaxed and disturbed by the burden which has been placed upon it, both as to volume and method. Even at the present time the so-called commuter system existing in connection with the older service of so many great railways is strained to a point which is making it unsatisfactory both to the railway administration and the traveler, and it is a question whether the breakdown of the whole inadequate arrangement is not imminent. The passengers are dissatisfied, both with the rates and the service, while the railroads are convinced that this portion of the business is both exasperating and unprofitable. Plainly, something will have to be done! In the meantime, there has been developed a complete transformation in the conduct of local transport within the city itself, and the electric tramway has superseded the omnibus, the horse-drawn car and the cable traction system. Electric railways on the surface, in underground tubes and on elevated structures have shown the way to rapid, effective and convenient local transport. These have been followed by interurban electric railways, and these, again, by the construction and operation of electric locomotives of sufficient power to haul standard railway trains through tunnels and into cities with the elimination of smoke and gases.

There has thus grown up, in parallel, the local passenger question and the apparent means of answering it. Just how the remedy is to be applied remains to be seen, but the most obvious method would seem to be the segregation of the local passenger traffic altogether from the long-distance service, and leave to the main-line railways the duty of transporting individuals and merchandise over the wider areas, freed from the burden of the troublesome and costly commuter, who would be far better served by such an extension of the local electric service as would carry him, without change, to his suburban home within a radius of, say, fifty miles. Such a solution of the problem would provide ample opportunity to discover the true efficiency of the electrical system, and would also put the claims of the advocates of the steam locomotive to the continuing test of the special service for which it is best adapted.

It should be remembered in all

such discussions, however, that the criterion of cost should be given only its relative weight in determining conclusions. The locomotive, and all that it involved, was far more costly than the venerable stage-coach system which it superseded; but that formed no argument or impediment to the change.

Changes are inevitable under the changing conditions which the advances of modern civilization are forcing upon us. It has been said of such a conservative reactionary as Talleyrand that if he had been consulted at the Creation he would have objected on the ground of the undesirability of disturbing the existing conditions of chaos. While such an extreme view is hardly conceivable at the present time, it is possible that there is a certain amount of mental inertia which should be taken into account.

In the following articles both sides of the subject are discussed by competent writers, and it should be remembered that a problem of such magnitude involves the maintenance of a quiet and judicial consideration if a solution of real value is to be reached.

THE OPERATION OF STEAM RAILROADS BY ELECTRIC MOTORS

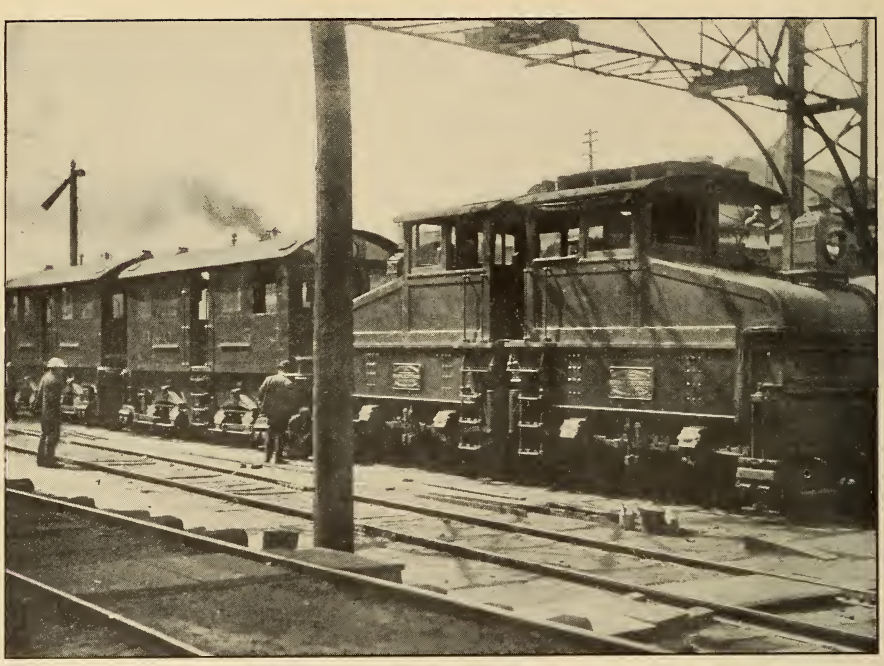
By J. B. Whitehead

THE first electric railroad operated by the motor must be admitted to be the line at the Berlin Exposition in 1879. Although but a thousand feet long, it demonstrated that this system of transportation is practicable. The first actual street railway equipped with motors in America was the 13-mile line built in the city of Richmond in 1888. Though but twenty-three years have elapsed, it is needless to say that, with the exception of a few cable and horse lines, all street transportation service is electric. Not until ten years ago, however, did the promoter take up the railways between cities, and, as might be expected, the Middle Western States in America contain the largest mileage of them, some of the lines being in the same district with one or more steam roads and in direct competition with them.

While the operations of the interurban lines have shown that all can be built and maintained at a lower cost per mile than the modern steam railway, and that the train service, while efficient, can be operated more economically, as yet practically all of the extensions of the older railway companies are still operated by the locomotive. The relaying of track and building of roadbed is for the heavier weight and larger engine—not with any view of electric transportation. Thus far the plans of the older companies for motors have been confined to a few instances, in most cases terminals in and approaches to cities, as the New York Central, the Pennsylvania, and lines running out of Chicago. The Long Island branch of the Pennsylvania and the New York, New Haven & Hartford are companies that have adopted the motor for a considerable distance.

This is the situation to-day, despite the fact that the majority of the experts on railway service and electrical engineers are frank to say that electricity has advantages over steam.

The operation of some of the interurban lines has been long enough to obtain accurate data on this point that cannot be contradicted, and investigations have been made, not of

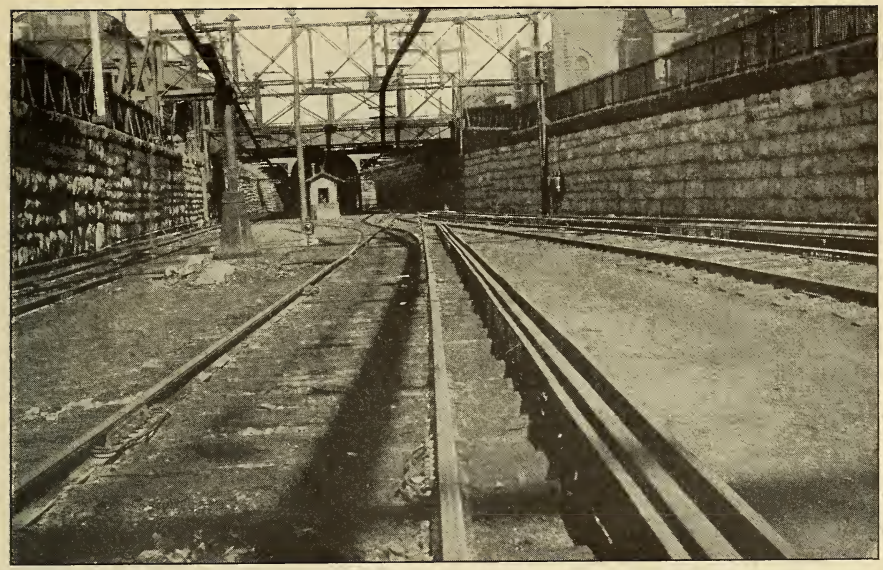


OLD AND NEW TYPES OF ELECTRIC LOCOMOTIVES USED ON THE BALTIMORE AND OHIO BELT RAILWAY OF BALTIMORE

one line, but a group of them, by the experts. The conclusions of one of them, Professor J. B. Whitehead, electrical expert of Johns Hopkins University, Baltimore, is of much interest, since Professor Whitehead has made a study of this subject practically covering the country and extending over a period of several years. In discussing the matter, this authority says:

"The total steam railway mileage in the United States aggregates about 240,000 miles of line, but it remains a fact that only about 1,000 miles of railroad formerly operated by steam have been transformed to the use of electricity as motive power. The question arises as to what conditions have started the present development and as to whether this beginning will extend itself in general degree to the large trunk line systems. It is not sufficient for the engineer of to-day to demonstrate the physical possibilities of a project, but he must go further and justify it on the grounds of business advisability and economy. If, then, it be asked why have steam railroads begun to substitute electricity as motive power, the answer is to be found in two broad reasons. The first of these is, that in some instances the use of electricity is the only possible way of handling the traffic. The second reason is the invariable one, in this commercial age, for all engineering enterprise—that it pays.

"It is admittedly true for the majority of steam roads of any considerable size and density of traffic that the operating expense would be substantially reduced by electric operation. Figures showing that this saving, together with the returns from increased business, is sufficient to offset the interest charges on the necessary capital, are still few. Such figures have, nevertheless, been given for existing roads on which the transfer to electricity has been made. As to competition, however, the public will invariably drift to an electric rather than a steam route between given points. Moreover, when a



SECTION OF BALTIMORE AND OHIO BELT RAILWAY, SHOWING OVERHEAD TRANSMISSION, NOW ABANDONED, AND THE PRESENT CURRENT RAIL SYSTEM

steam road is paralleled by electric service, not only does the latter take the bulk of the traffic, but the traffic itself increases in volume. Further, when a sparsely settled section is penetrated by an electric road, population and consequent business follow promptly. These facts are now matters of common observation. One extreme example will indicate the lengths to which these facts may go. A steam road in the Middle West

THE ELECTRIC ROAD OF THE BALTIMORE AND OHIO SYSTEM

This was the first to utilize electric power for train service.

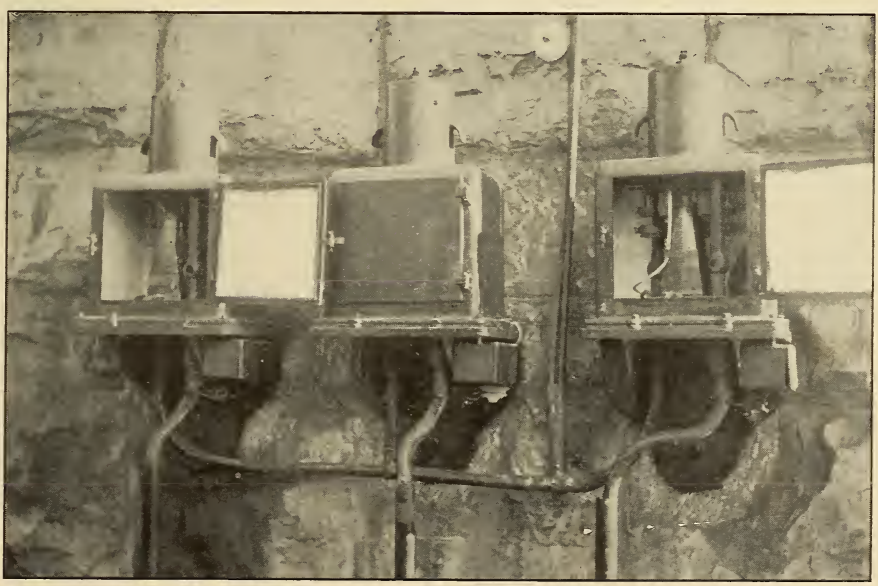
CONTACT SHOE USED ON THE BALTIMORE AND OHIO ELECTRIC LOCOMOTIVES

was paralleled by an electric line; the latter took away over 50 per cent. of the steam traffic and increased the total traffic fifteen times the original amount within seven years.

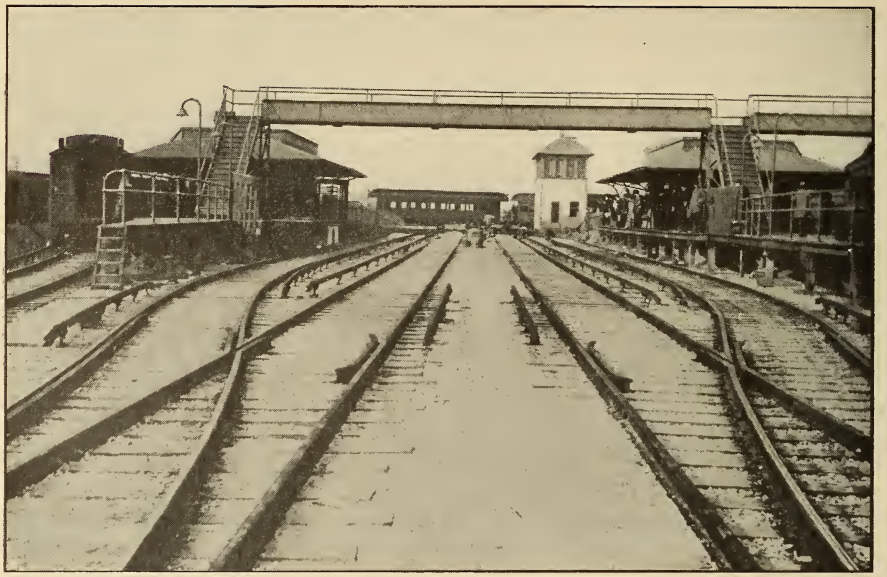
"If we look for the reasons for such advantages in absorbing and promoting traffic, we realize that electric travel is faster, more frequent and more comfortable. It provides freedom from smoke, better ventilation, easy regulation of light and heat, and, in fact, travel in many instances is actually a pleasure. An electric locomotive or train can be operated at a higher schedule speed than is possible under steam. The elapsed time of a suburban train between stops depends principally on the rapidity with which it attains its maximum speed. The rate at which it reaches this speed—that is, the acceleration—depends on the value of the pull exerted by the motive power. During the period of starting, the greatest draw-bar pull is required, since during this time the inertia of the mass of the train must be overcome. After reaching a maximum speed the only forces to be overcome are those of frictional resistance of the track and the air. In a steam locomotive the greatest draw-bar pull being required at starting, steam is admitted to the cylinders throughout the full length of the stroke. The demand on the boiler per revolution is, therefore, greatest at this time. No locomotive can, on the average, exert a greater pull than 25 per cent. of the weight carried by its own driving wheels, for beyond this figure the wheels will slip on the track. The boiler capacity, therefore, is designed to give no more steam than that demanded by this value of the pull at starting. A steam train, therefore, does not utilize the weight of its own cars as a means of increasing its grip on the rails. In a multiple-unit electric train motors are placed on each car, thus utilizing the weight of the entire train for frictional adhesion to the rail. By electric control of the motor switches all the motors may be operated simultaneously by one man at the head of the train.

By this system the draw-bar pull per ton of train may be increased from 2.5 to 4.5 times that for steam, and the rate of acceleration is only limited by the comfort of passengers. As a direct result of this schedule speed is increased, the headway between trains is reduced, and more trains may be operated on the line. By the use of electric locomotives in terminals for switching service, great economies are effected. Since the electric locomotive operates in either direction and takes its entire power supply from the trolley or third rail, much useless mileage of locomotives in going to and from the turntable, the water-tank and the coal-chute is avoided. The New York Central Company reports, as a result of tests, a net saving of 21 per cent. on the cost of switching service and 16 per cent. in the ton-mileage of switching locomotives.

"For long-haul passenger and express service rapid acceleration is not so important, but the maximum speed becomes the determining factor in a fast schedule. For any type of motive power the draw-bar pull is greatest at starting, and falls to a lower and lower value as maximum speed is approached. Consequently, for this class of service large initial effort is not so important as large effort at high speed. In this respect the electric motor has a great advantage over the steam engine. Since the boiler of the steam locomotive is proportioned to the maximum demand which it can generate at starting, corresponding to the grip which it has on the rails, at higher speeds the steam must be cut off from the cylinders at a less and less fraction of full stroke, for otherwise the boiler cannot supply steam fast enough and still maintain its pressure. Thus, the total tractive effort, which depends on the proportion of a revolution during which steam is admitted to the cylinders, is reduced as the speed increases. While the tractive effort of the electric motor also increases somewhat with the speed, it does not do so nearly as rapidly as that of the steam locomotive. As a consequence, a given weight of train can be handled faster by electricity than by steam, or a heavier train may be hauled at a given maximum speed.



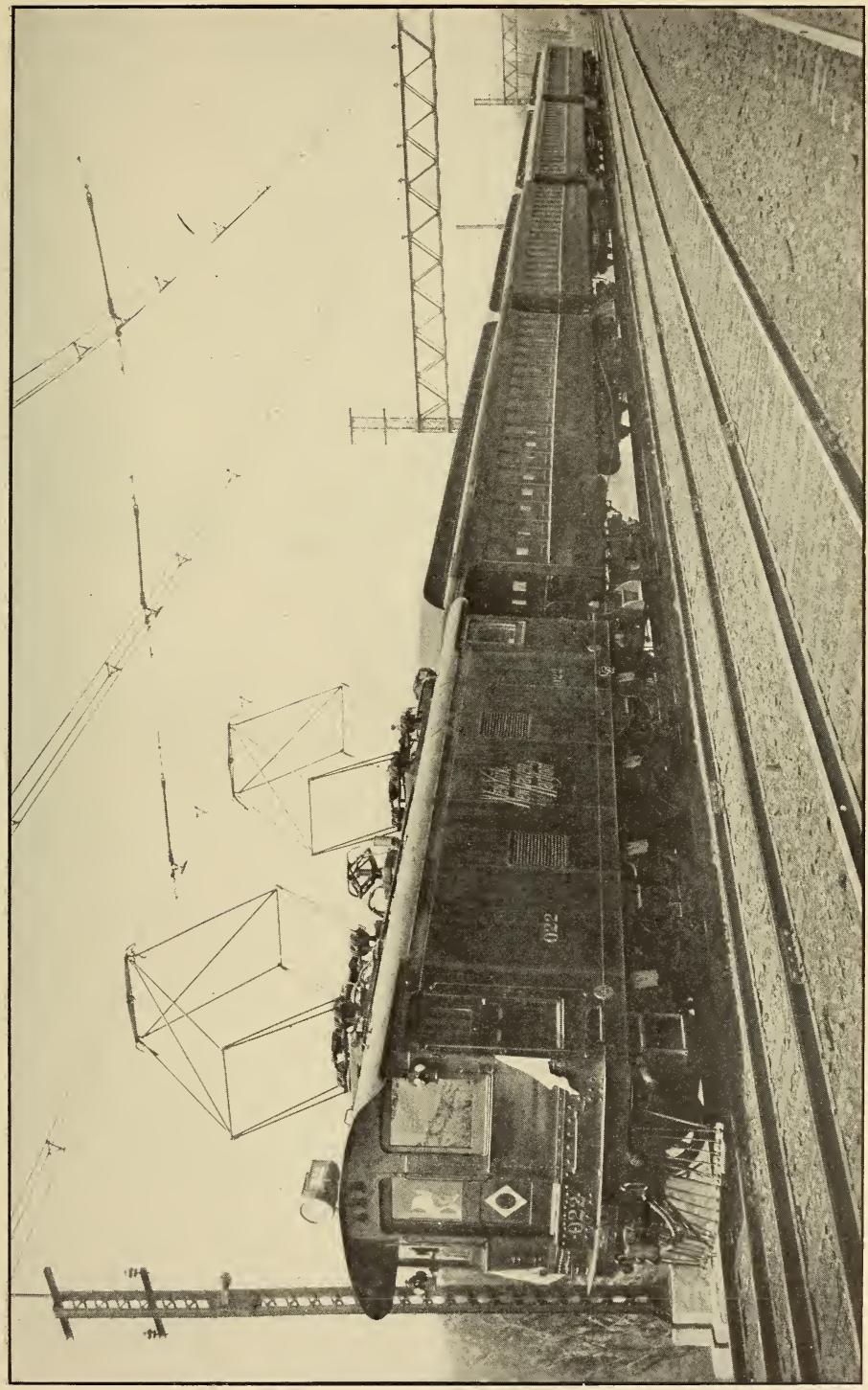
AUTOMATIC SWITCH CONTROL ON THE BALTIMORE AND OHIO SYSTEM



SWITCH TRACKS ON THE AURORA AND CHICAGO RAILWAY
Current rail is cut off and current carried in underground conduits constructed to prevent accidents

"Again, the safe limits of speed are much higher in electric operation. The rotative effort is uniform in a motor, while that of a locomotive is intermittent and accomplished through the medium of heavy reciprocating parts. The moving mass of these parts as the speed increases tends to lift the locomotive from the track and pounds the rails with a

SECTION OF AURORA, ELGIN AND CHICAGO RAILROAD, SHOWING ELECTRIC EQUIPMENT



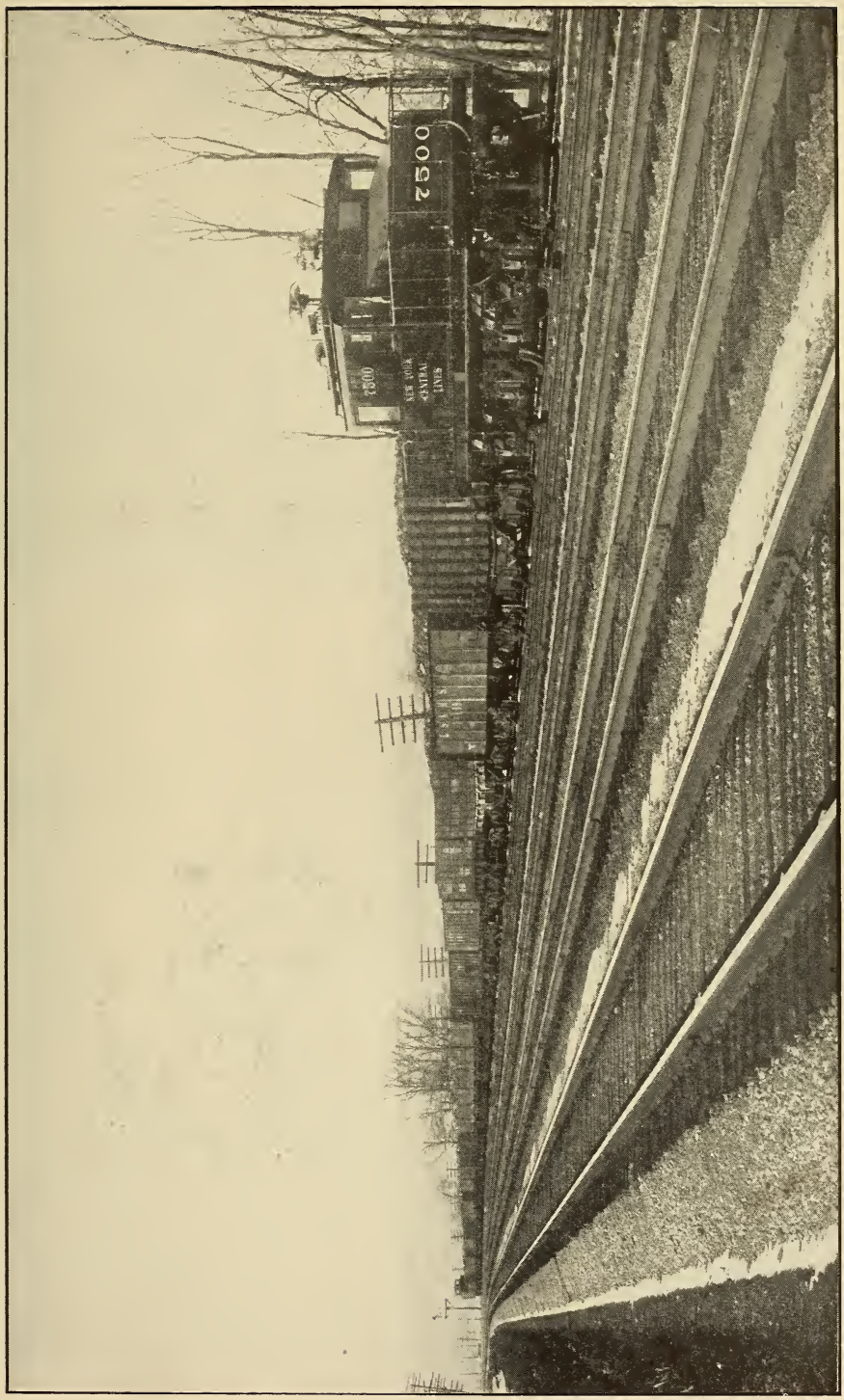
ELECTRIC LOCOMOTIVE AND TRAIN ON THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD, USING ALTERNATING CURRENT. WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

ELECTRICALLY OPERATED SYSTEM OF THE ORLEANS RAILWAY IN PARIS

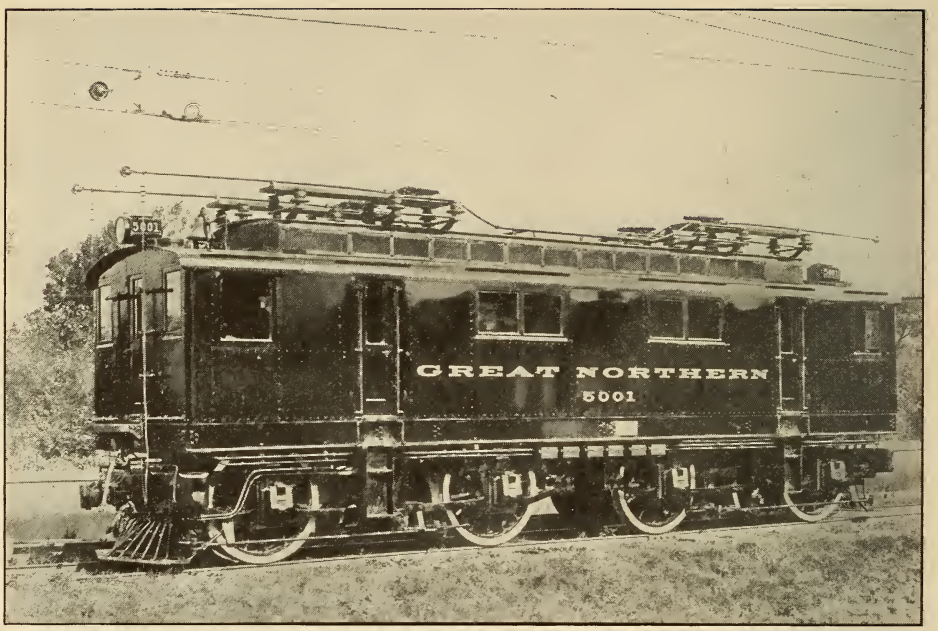
blow which, in many instances, has been sufficient to cause derailments. The limiting speed of steam trains is about 80 or 90 miles per hour, while speeds of 130 miles per hour have been reached in tests on electric trains.

"The advantages of electricity for freight traffic are most apparent on long, single-track lines with heavy

ELECTRICALLY OPERATED TRAIN ON THE PARIS METROPOLITAN RAILWAY



ELECTRIC LOCOMOTIVE HAULING 1,400-TON FREIGHT TRAIN THROUGH THE DETROIT RIVER TUNNEL. BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.



ELECTRIC LOCOMOTIVE BUILT BY THE GENERAL ELECTRIC COMPANY FOR THE GREAT NORTHERN RAILWAY

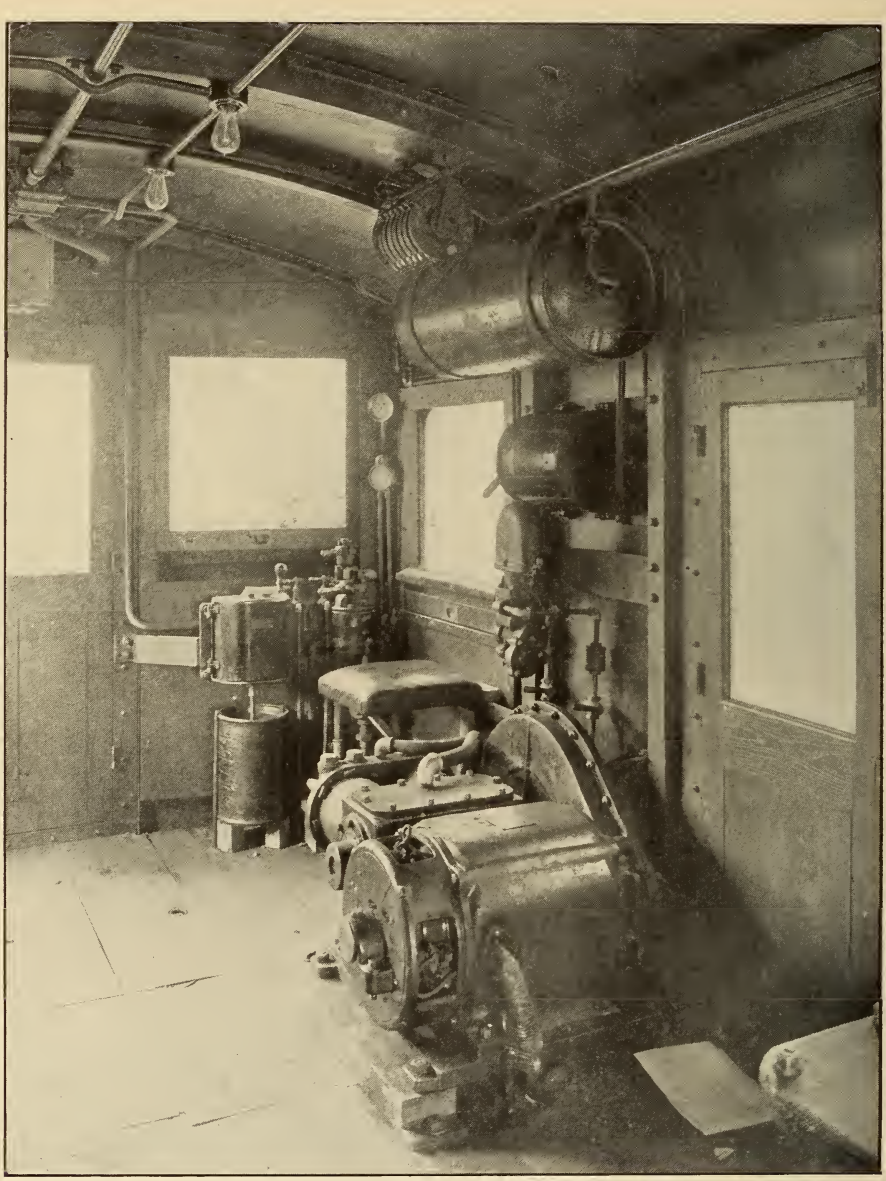
ELECTRIC LOCOMOTIVE IN USE ON THE FORT DODGE, DES MOINES AND SOUTHERN RAILROAD
Built by the General Electric Company.

SINGLE-PHASE ELECTRIC CARS ON THE SPOKANE AND INLAND RAILWAY. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

grades and mixed traffic. The length of the freight train of to-day is limited by the draw-bar pull of the locomotive, which is, in turn, dependent on the locomotive weight and by the schedule speed. Speaking generally, longer trains, and hence fewer trains on the line at one time, are to be had only at great sacrifice of speed. The longest freight trains weigh from 2,000 to 3,000 tons, and are operable only on level track. On reaching mountain grades such trains have to be broken into two or three parts, which, therefore, on single-track roads, increase the number of passing points and subsequent delays, thus rapidly shortening the headway between trains and filling the line to its capacity. Schedule speeds on such grades now average about 10 miles per hour. The operation of two or more locomotives in a train is not satisfactory, owing to the impracticability of securing simultaneous cooperation of the several motive units.

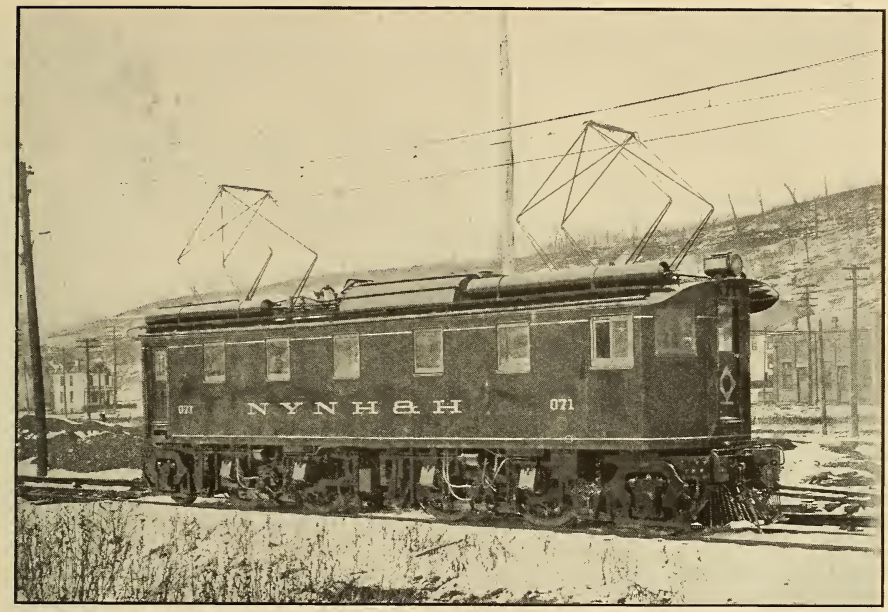
"As already stated, the tractive effort at high speeds is much greater for the motor than for the steam locomotive; hence, in the case of electric operation, the limiting weight of the train on grade is higher; also, the schedule speed may be largely increased by the use of double or triple headers. This method of operation is perfectly possible under electricity by the system of multiple control, already mentioned, and the length of a train is limited only by the strength of the draft gear. This limit would disappear if all freight cars could be equipped with a simple standard cable, enabling the placing of an electric locomotive in the middle or at the end of a train. This cable would be necessary to secure the simultaneous operation of the several locomotives.

"A few comparative figures of the possible methods of increasing railway business are not without interest. A typical Western freight locomotive, weighing, with its tender, 165 tons, can develop continuously a draw-bar pull of 25,600 pounds up to a speed of 15 miles per hour. An electric locomotive weighing 100 tons can develop this value of pull up to a speed of 37 miles per hour. Another similar type of electric loco-



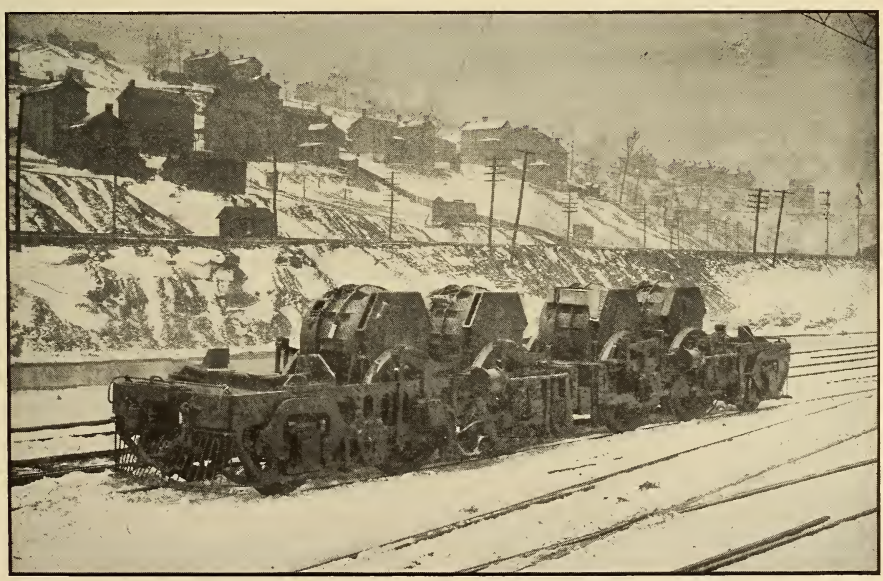
INTERIOR OF OPERATING SECTION OF MOTOR CAR

motive gives 56,800 pounds up to 23 miles per hour, and still another 8-motor type can develop 113,600 pounds draw-bar pull up to a speed of 23 miles per hour. A late type of Mallet compound locomotive, weighing 300 tons, can develop continuously 2,180 horse-power at its driving wheels. A New York Central electric locomotive can do the same, and weighs only one-third as much. The cost of each locomotive is about the same. It may be noted that 200 ton-miles are saved in every locomotive-mile if the electric locomotive is used instead of the steam locomotive. At 40 cents per locomotive-mile and 100 miles per day,



FOUR-MOTOR GEARED FREIGHT AND PASSENGER LOCOMOTIVE FOR ALTERNATING AND DIRECT CURRENT. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

the saving is $40 per day, or about $15,000 per year. The saving on this account alone would, in two years, pay for the electric locomotive. Another type of Mallet locomotive, weighing, with its tender, 250 tons, can haul a train weighing 330 tons up a 2.2 per cent. grade at 15 miles per hour. A 100-ton electric locomotive can haul a train of 800 tons under the same conditions. The total train weights are thus 580



MOTORS AND RUNNING GEAR OF LOCOMOTIVE SHOWN ABOVE

ROADBED AND STATION ON THE LACKAWANNA AND WYOMING VALLEY ELECTRIC RAILWAY

and 900 tons, and the electric locomotive weighs 100 tons less than the steam locomotive, resulting in the consequent saving in the ton mileage of dead weight.

"The operating conditions and the reliability of service are improved in all classes of traffic by the substitution of electricity. The construction of the electric locomotive is far simpler. The steam locomotive comprises firebox, boiler, steam engine and facilities for handling coal and water. The electric locomotive, on the contrary, consists only of the electric substitute for the engine, and this substitute has no reciprocating parts. There is, consequently, less wear and tear and less likelihood of derailment and broken rail. The firebox and boiler are absent as sources of danger in a collision, as are also apparatus for steam or fire heating and oil or gas lighting. Signals are clearer in the absence of smoke, and automatic signals are possible, though as yet they are little used. The control of power to trains in sections or blocks is also possible. The number of car miles per train-minute of delay has been nearly doubled on the elevated lines of New York since the electrical operation was inaugurated. Less time is required for clearing and despatching trains, water and coal stops are obviated, and less attention is required for light and heat. The electric locomotive is always ready, requiring no time for firing.

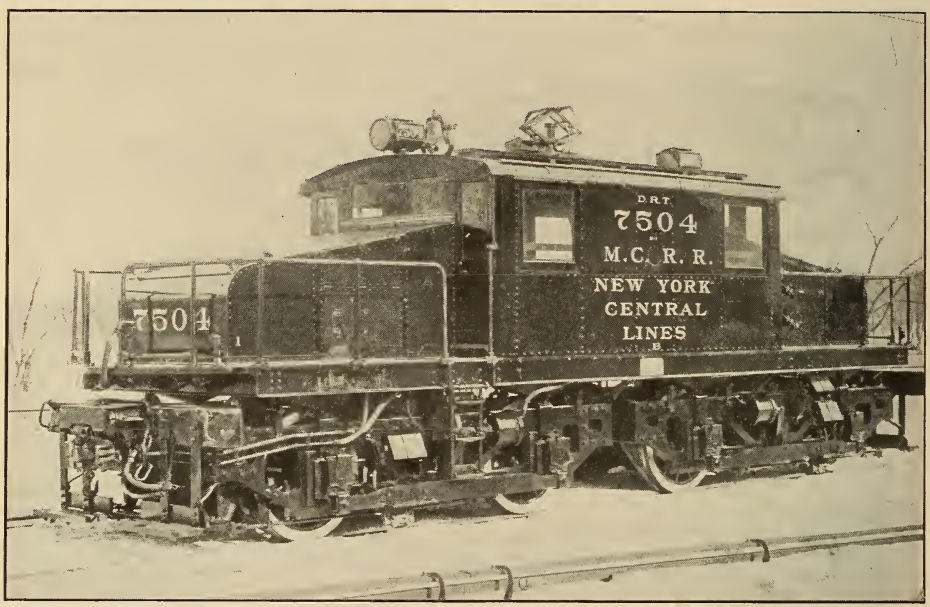
"To compare the cost of steam and electric service, figures are available. The operating expenses of an average steam railroad may be roughly divided as follows: Maintenance of way, 21 per cent.; maintenance of equipment, 19 per cent.; conducting transportation, 56 per cent.; general expenses, 4 per cent. Considering these items under electric operation, the greatest saving is effected in the item of conducting transportation, which includes the cost of coal. The steam locomotive consists of a boiler and engine. The same amount of coal in a locomotive boiler will evaporate only about two-thirds as much water as in a stationary boiler. The average steam consumption of a good locomotive engine is about 30 pounds of steam per horse-power-hour developed; turbo-generators are now guaranteed for a consumption of only 15 pounds of steam per electrical horse-power at the switchboard. As offsetting these marked

advantages, it is necessary to consider the electrical losses in the transmission system and in the motor equipments. Speaking roughly, 75 per cent. of the electrical energy supplied by the switchboard is available at the wheels of an electric train for tractive effort. These figures indicate that an electric locomotive requires less than one-half the amount of coal used by steam locomotive giving the same horse-power output.

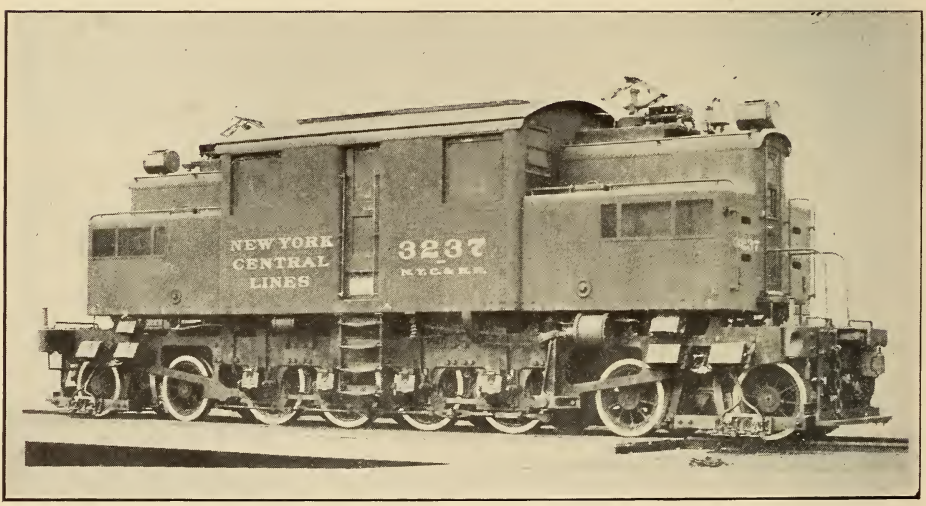
TRACK OF THIRD-RAIL ELECTRIC LINE BETWEEN SCRANTON AND WILKESBARRE, PA.

Further than this, it has been estimated that for every hour that a locomotive is standing idle with steam up, 400 pounds of coal are burned. The excess of useless mileage and the excess ton mileage owing to the greater weight of the steam locomotive have already been noted, and are also causes for excess coal consumption. As opposed to these, there is the light load coal consumption of the power station. The final value of the balance in coal saving will depend on the proportion of time in which the power station operates to its full capacity. Based on careful comparative tests of steam and electric locomotives, the engineers of one of the large power stations have announced that the electrical operation of the former steam service is being maintained with the consumption of only 60 per cent. of the amount of coal, resulting in a saving of nearly $350,000 per year. Figures have been published showing that the Manhattan Railway under steam operation secured about 1.5 tonmiles to a pound of coal; under electric operation this figure has increased to 3.85. These and other careful estimates indicate that in the general electrification of through railway lines a saving of 50 per cent. in coal consumption may be effected."

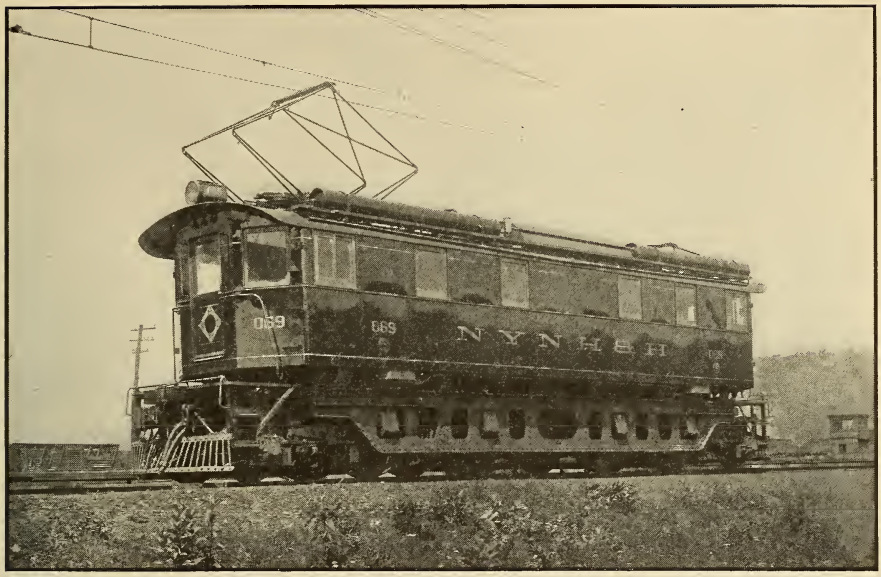
One reason given why the railway companies are so reluctant to substitute electricity for steam, in spite of the fact that its advantages are apparent, is because they are undecided as to the most practical and economical system of the operation. No less than four have been



ELECTRIC LOCOMOTIVE BUILT BY THE GENERAL ELECTRIC COMPANY FOR THE DETROIT RIVER TUNNEL SERVICE



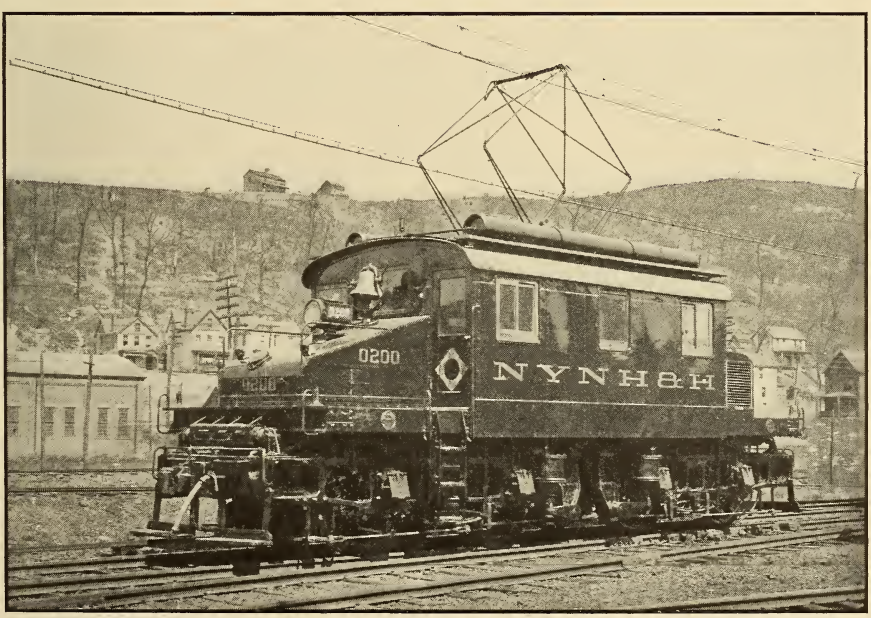
ELECTRIC LOCOMOTIVE FOR THE NEW YORK CENTRAL LINES. BUILT BY THE GENERAL ELECTRIC COMPANY



EIGHT-MOTOR WESTINGHOUSE GEARED FREIGHT AND PASSENGER LOCOMOTIVE FOR ALTERNATING AND DIRECT CURRENT

considered by the electric experts for long-distance work. The opinion of many experts is that the system must be adopted especially suited to the mileage, the grade and the frequency and size of the trains. Prof. Whitehead, may be quoted as follows:

"In the United States the best engineering opinion seems to have united in thinking that the single-



SINGLE-PHASE ELECTRIC SWITCHING LOCOMOTIVE. WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

phase system is the one best adapted for future application to steam railways. This system is as yet only four years old, yet there are at present over 1,000 miles of railways in the United States operating under it, and in this aggregate there are at least five railroads formerly operated by steam. The system has proved most successful in operation, although the first six months' operation of the New York, New Haven & Hartford Railroad has developed so many unforeseen troubles, when applied to such a large enterprise, as to bring upon it much adverse criticism. On the other hand, the high degree of perfection to which the direct current system has been brought, the greater capacity of the motors of this system and the enormous mileage already installed in tunnels and terminals have resulted in a strong advocacy of this system. Speaking generally for motors of equal weight, that of the direct current system has 25 per cent. more capacity than that of the alternating current system. The equipment of a high-speed interurban car having four motors of approximately 100 horse-power capacity will weigh under the direct current system 22,500 pounds and under the alternating system 32,000 pounds, or nearly 50 per cent. excess over the direct-current equipment. For the entire car, however, the excess weight would be only about 12 per cent. The excess in cost would be about 35 per cent. In the case of locomotives the excess weight of the alternating-current equipment is even greater. The New York, New Haven & Hartford alternating locomotive has about the same weight as the New York Central direct-current locomotive; but, if compared on the basis of maximum tractive effort, the former weighs twice as much. The two locomotives are, however, designed for different service, and the comparison is much more favourable to the alternating current system if based on the continuous capacity. The cost of each of these locomotives is about the same."

THE ELECTRIFICATION OF STEAM RAILWAYS

By Arthur Curran

SINCE the introduction of electric power for terminal, tunnel and similar service on steam railways there has been much discussion as to the possibilities of this form of motive power. Conservative railroad men have consistently opposed its use, while enthusiastic electrical engineers have urged its immediate and general employment.

The controversy has, at times, become very active, the railroad men feeling that they were being unduly urged toward unnecessary and excessive expenditures, while electrical engineers have believed that they were subjected to unwarranted criticism.

Perhaps the best way to deal with the subject will be to examine its historical aspects.

It must be understood from the start that there is no quarrel between railroad and electrical engineers, as such, and that the only thing to be desired is an accurate presentation of the situation to the public.

The first electrical installation coming within the purview of this article is that made in Baltimore about sixteen years ago. Additions, of course, have been made to this equipment, and will probably be made in the future, not because of any extension of the system, but because of changes in conditions. The electric

DOUBLE-UNIT LOCOMOTIVE ON BALTIMORE AND OHIO ELECTRIC BELT LINE IN BALTIMORE

locomotives are operated on the Baltimore & Ohio Railroad between Camden Yard and Waverly, a distance of something more than three miles. In this stretch there are several grades and tunnels, and a steam locomotive would, doubtless, make much noise and smoke. It was to obviate these points that the electric locomotives were introduced, and, to meet the desire of the citizens of Baltimore, they still remain. These electric locomotives were built by the General Electric Company, and have a free running speed of about 20 miles an hour, and a hauling capacity of about 3,000 tons on a level, weather permitting.

Mr. J. E. Muhlfeld, during the time that he was superintendent of motive power on the Baltimore & Ohio Railroad, made a careful study of the situation at Baltimore, and incorporated the results of his experience in a paper which he read before the New York Railroad Club.

His conclusions were decidedly unfavourable to electrification, and although they were met with a storm of protest from the electrical engineers at the meeting, he maintained his attitude, and has not, so far as can be ascertained, had any occasion to change his opinion. His successors have had little to say about the matter one way or the other. This installation is of peculiar interest, inasmuch as it represents the first instance in which the steam locomotive was supplanted through no fault of its own, but merely to meet local conditions.

The next example of electrification to be considered is that of the New York Central Railroad.

It is about ten years since an unfortunate accident in the Park avenue tunnel, at New York, caused an agitation which cost the New York Central more than a hundred million dollars. While this huge expenditure was immediately caused by the accident, it must be admitted that electrification would have come, sooner or later, in any case. For a portion of its length Park avenue is considered as a desirable residential section, and the occupants of the dis-

trict felt that the railroad should yield to their interests. Had such a contingency been foreseen it is improbable that the terminal would have been located in the vicinity of such valuable real estate. Some critics of existing methods in municipal affairs regard this as a conspicuous instance of the haphazard manner in which many cities have been permitted to develop. In fact, the view is now sometimes held that railroad terminals in cities are unnecessary, and are, in the long run, more of an obstruction to traffic than an aid to its development. The assertion is made, and with truth, that a terminal merely constitutes a focus for crowds and an unnecessary point of congestion. There appears to be a remedy for this state of affairs, which, being intimately connected with electrification as a proposition of the future, will be referred to later on.

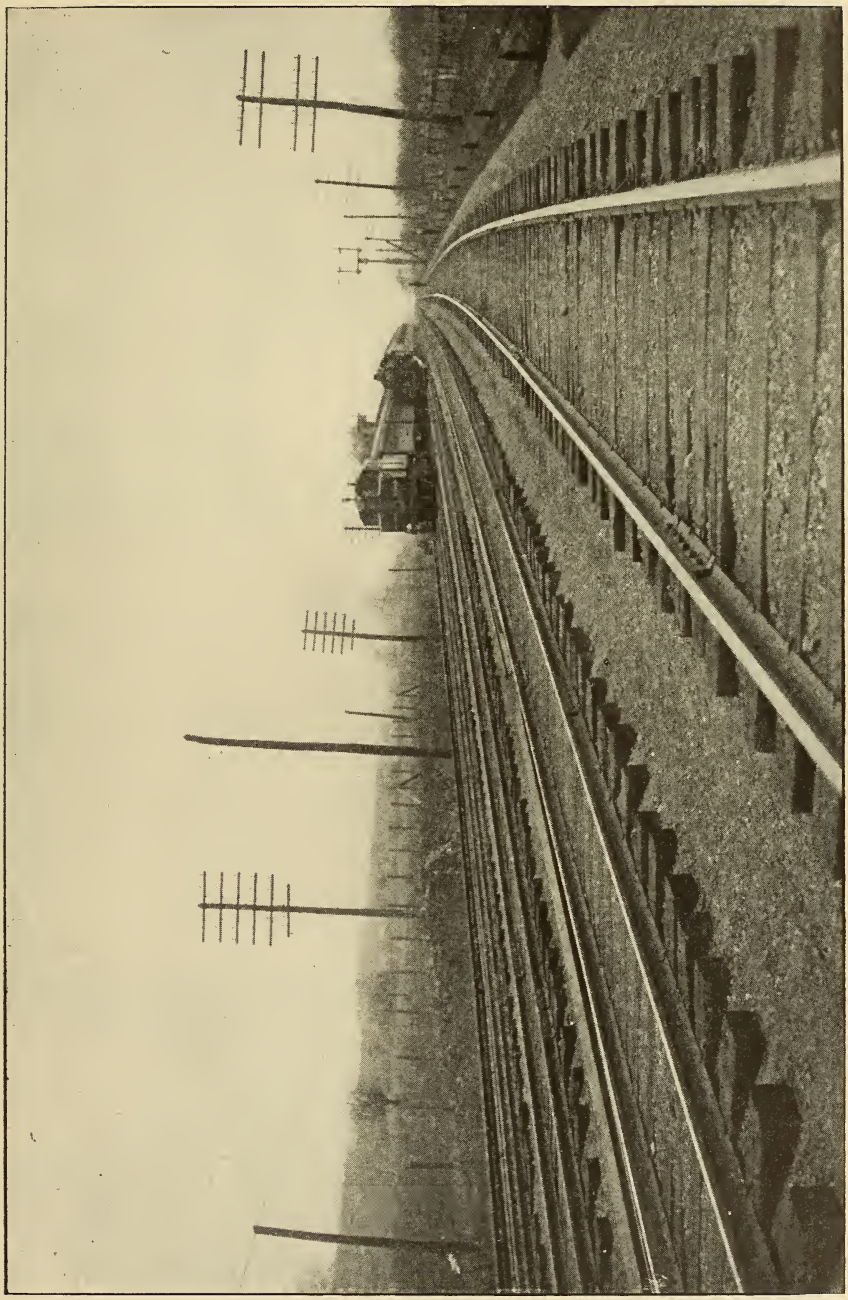
In any case, the New York Central was confronted with a serious problem. The north portal of the tunnel did not afford facilities for changing locomotives, as the tracks were carried on a viaduct from that point to the Harlem River. The yard just north of Mott Haven was devoted to a variety of uses and could not be considered. It was, therefore, decided to haul the important express trains as far as High Bridge, where there was room to build a roundhouse, and take off the electric locomotives at that point. Since it would be necessary to generate a large amount of current for such heavy service, it was seen that local trains could be operated by the multiple-unit system as far as Croton-on-the-Hudson and to White Plains, on the Harlem division. The arrangement, as will be seen, was brought about by the peculiar circumstances of the case and not because of the choice of the company.

At the present time the work of making these changes has progressed to a point where some conclusions are warranted. Through trains are hauled from the station at Forty-second street by electric locomotives as far as High Bridge. These locomotives were built by the General Electric Company, and are designed to take current from a third rail. They are noteworthy because of their capacity to haul a heavy train singly, thus avoiding the coupling of two "units," required in other cases. The distance from the Grand Central Station to High Bridge, however, is only about seven miles, and cannot be taken very seriously. The multiple-unit suburban trains are run as far as Hastings-on-the-Hudson, and in due time will probably be run to Croton. The Harlem division is already being operated in accordance with the original plans.

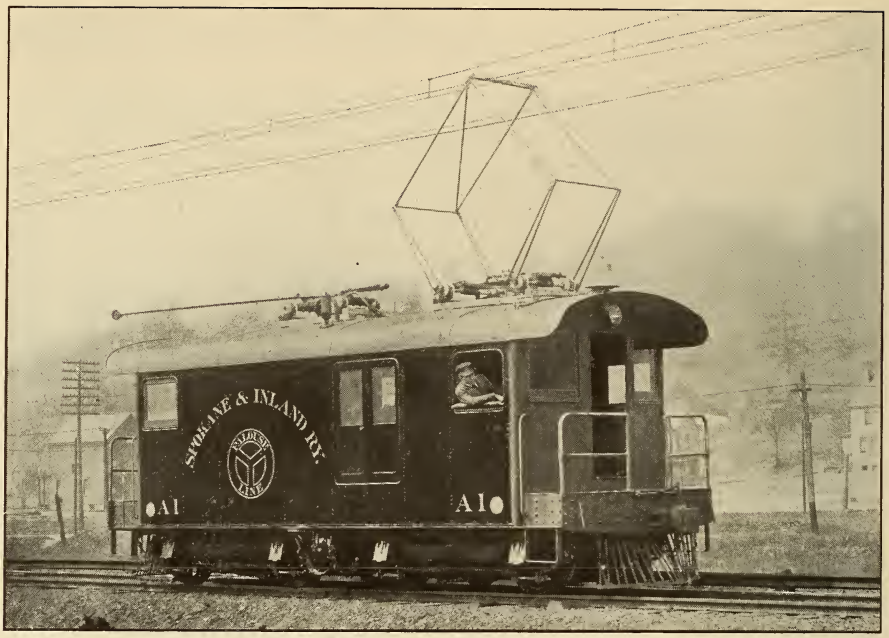
Thus far, the officials of the New York Central Railroad have not exhibited any enthusiasm. If they are pleased with the results they have kept very quiet. The new terminal in New York City is not finished, and the time for its completion appears to be uncertain. In any case, no startling exhibitions of speed have been made, either by the electric locomotives or by the multiple-unit trains. The steam locomotives, however, are still making speeds of a mile a minute or more.

As the New York, New Haven & Hartford Railroad uses the Grand Central terminal in New York City, and its trains pass through the Park avenue tunnel also, it found itself under the necessity of providing for electrification at that point. It did not, however, elect to use the same system as the New York Central, but installed the single-phase alternating current, with apparatus built by the Westinghouse Electric & Manufacturing Company, using overhead conductors. This required the installation of two different systems in the portion of road used by both railroads.

It is announced that the New York, New Haven & Hartford Railroad has decided to extend the electrification of its system from Stamford, 34 miles from New York, as far as



SPEED TEST BETWEEN ELECTRIC LOCOMOTIVE AND STEAM LOCOMOTIVE ON NEW YORK CENTRAL RAILROAD. ELECTRIC LOCOMOTIVE BUILT BY THE GENERAL ELECTRIC COMPANY FOR THE NEW YORK CENTRAL RAILROAD



WESTINGHOUSE ELECTRIC LOCOMOTIVE ON THE SPOKANE AND INLAND RAILWAY

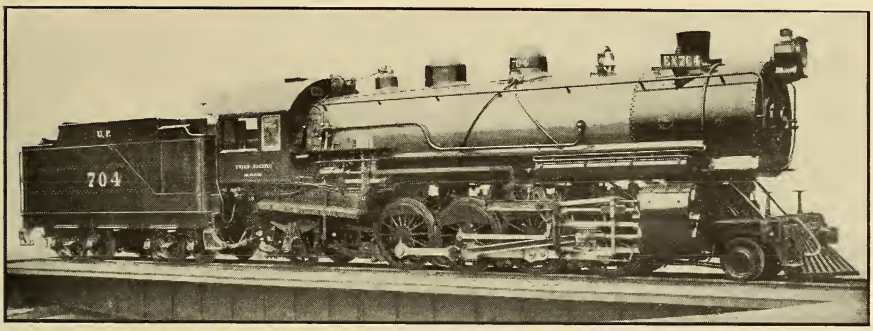
New Haven, which is about 73 miles altogether. This line, however, passes through a very populous district, and its passenger traffic from New Haven to New York City is rather of the nature of local than through or long-distance business, and hence the results of its electrification cannot be taken as an indication of what may be done under wholly different conditions.

The Pennsylvania Railroad has provided another example of electrification, of which the Long Island Railroad properly forms a portion.

A number of years ago it was thought that the several railroads terminating in Jersey City would build a bridge across the Hudson River and a union station in Manhattan. Various difficulties appeared to prevent the consummation of such a plan. The National Government forbade the construction of piers in the river, as constituting obstructions to navigation, while the difficulties in securing franchises for terminal construction in New York were insuperable.

The effects of this policy as regards the construction of railway facilities in New York may be briefly considered here. It is evident that Manhattan Island is not destined to be used wholly for residential purposes and for a moderate variety of business enterprises, but that it is pre-eminently adapted for commerce in the widest sense of the word. The most desirable use to which the land along the water front can be put is for railroad and steamship service, instead of allowing the existence of dirty and dangerous slums. Even the handsome residential section of Riverside Drive might well be replaced by the buildings of commerce rather than permit such a location to be occupied by a limited number of householders.

It was to a city in which such difficulties appeared that the Pennsylvania Railroad sought an entrance. The only solution of the problem appeared in the construction of subaqueous and subterranean tunnels, which necessarily involved electrical operation. This much admitted, the tunnels extending eastward to connect with the newly acquired Long

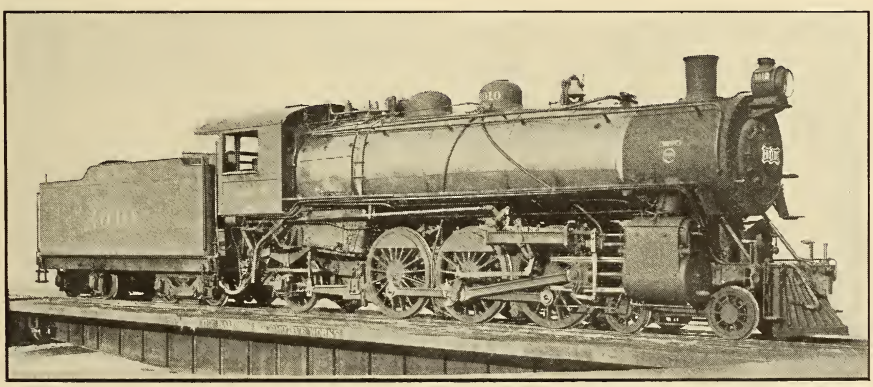


MIKADO TYPE LOCOMOTIVE FOR UNION PACIFIC RAILWAY. BALDWIN LOCOMOTIVE WORKS

Island Railroad came as a matter of course. Thus, it will be observed, the use of electric traction was adopted only in the absence of an alternative, and not on its own merits. It was found practicable to secure permission to construct a subway across Manhattan where a viaduct would not be permitted. The present magnificent station was built, and thus a satisfactory entrance to New York created.

Although the Long Island Railroad shares this station as a subsidiary of the Pennsylvania, its problems were somewhat different. When the Pennsylvania Railroad secured control of the Long Island Railroad it was evident that something would have to be done. Mr. Ralph Peters, when he took charge as president, found the road in pretty bad shape; some of the engines and cars were fairly good, but most of the equipment was obsolete. The main line and the Montauk division were of fair length, but the rest of the system consisted of numerous short branches radiating from Long Island City, these latter demanding good local service. To have operated them by steam when electric power was available would have been poor policy. The extension of the Interborough subway to Brooklyn gave the Long Island terminal at that point an added value. Thus it was that electric power gained favour on that road.

In the operation of the Long Island Railroad the greatest patience and moderation has been exhibited in the face of much captious criticism, and the road has been improved to an extent which commands the



PACIFIC TYPE LOCOMOTIVE ON CHICAGO AND EASTERN ILLINOIS RAILWAY, EQUIPPED WITH SCHMIDT SUPERHEATER. BALDWIN LOCOMOTIVE WORKS

respect of all impartial persons. The best steam equipment owned by the road is now used for the longer runs, while the antiquated rolling stock has been replaced by electric trains for the suburban business. All things considered, the electrification of the Long Island Railroad has had a good effect; but it is not likely that similar conditions will be found elsewhere, and it would be unwise to draw any broad and general conclusions from the data thus obtained.

There are several other examples of electrification upon steam railroads, but of these only three demand any especial notice.

One instance is furnished by the subaqueous tunnel between Sarnia, Ontario, and Port Huron, Mich., on the Grand Trunk Railway of Canada. Traffic through this tunnel, which was built a number of years ago, was until recently handled by steam locomotives of special design. When these engines became obsolete, it was decided to introduce electric power instead of replacing them with steam locomotives. This step was so obvious as to demand no explanation, while the electric locomotives themselves included nothing remarkable or unusual which would call for extended comment.

A short section of the Great Northern Railway has been electrified, this including several gradients and a tunnel. The principal reason for making the change was the impracticability of removing the smoke which became pocketed in the tunnel. In addition to this fact, the railway had access to suitable water-power, which gave especial opportunity for cheap electric current. Thus, it will be observed that the inevitable peculiarity of circumstances is sufficient to account for the change.

For a number of years the Michigan Central Railroad has been obliged to carry its trains across the Detroit River upon ferryboats between Detroit, Mich., and Windsor, Ontario. The river is usually crowded with steamboats, and a bridge was out of the question. A tunnel was, therefore, constructed, and the installation of electric power naturally followed.

Too much emphasis cannot be placed upon the fact that local conditions have had more to do with the prominence gained by electric traction during the past few years than any other influence. No amount of theorizing can furnish any other explanation of the matter.

The brief references which have been made to the principal electrical installations, with necessary comments, should suffice to place before the impartial reader the real status of electrification in the United States and Canada. Having thus considered the subject from the historical viewpoint, it may be permitted to take up some further facts which bear important relations to the general proposition.

In the first place, it must be thoroughly understood that the vast majority of the railroads in the United States are not interested so much in the details of electrical equipment, or in the claims of different systems, as in practical demonstrations of what electricity can do, and at what cost a given amount of work can be done. In the past there has been nothing available upon either of these points beyond the assertions of electrical engineers.

It has been asserted that there are many places in which steam locomotives could be superseded to advantage and profit by the railways. Concerning this Mr. J. E. Muhlfeld says:

"However, before electricity can supersede steam for tonnage service it must be demonstrated practically from actual installation and operation, and not theoretically, that the results which electrical engineers are predicting will be forthcoming, as railroads are not generally making heavy expenditures to increase the business and revenue and reduce the operating expenses unless they have reasonable assurance of the net results."

Mr. Muhlfeld made this remark

several years ago, but the questions involved are still obscured and nebulous. Clearly defined proofs of the superiority of electricity are as yet lacking.

Coming now to another phase of the situation, Mr. Muhlfeld remarks:

"It has been said that, for the handling of heavy tonnage, electric locomotives have extreme advantages, especially on heavy grades, in regard to speed; this on account of the steam locomotive not having the same endurance, due to a limited supply of steam. Up to the present time, from actual performance, it has not been found that electric locomotives, having almost equivalent tractive power, when handling heavy tonnage on severe grades or curves, can operate at greater speed than steam locomotives."

And then:

"The working capacity of an electric locomotive having a total weight of 160 tons, with 42-inch diameter driving wheels, at a speed of 10 miles per hour on a 1 per cent. grade, is about 1,500 tons in the train, excluding the locomotive. The working capacity of a steam locomotive having a weight of 167 tons for the engine and an average weight of 58 tons for the tender, with 57-inch diameter driving wheels, at a speed of 10 miles per hour on a 1 per cent. grade, is about 2,200 tons in the train, excluding the weight of the engine and tender."

Mr. Muhlfeld found the electric locomotives more costly in every way than steam locomotives, "and there has been no benefit with respect to increasing average speed on 1 per cent. grade." Not very flattering for electricity, to say the least!

He also found the cost of electric power generating plants entirely too high. To quote him:

MULTIPLE-UNIT ELECTRIC TRAIN ON COEUR D'ALENE AND SPOKANE RAILWAY

"Under the average conditions the actual cost for the complete installation will range from $100 to $150 per horse-power developed, which is from seven to ten times the cost per horse-power developed in the ordinary types of locomotives at a speed of 10 miles per hour."

Moreover, he discovered that:

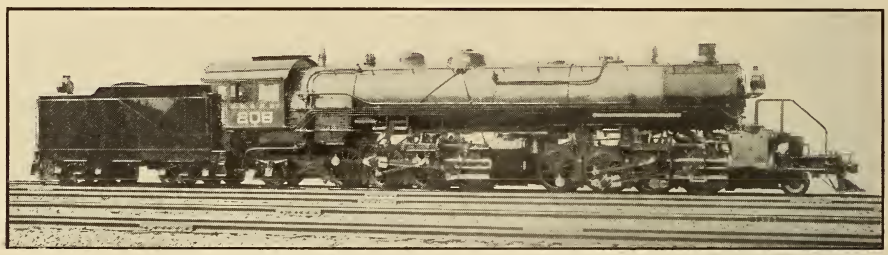
"The cost for coal, ash and water supply, storage and distributing appliances, as well as the expense for generators, high-tension lines, transformers, exciters, converter and feeder switchboards, all contribute largely to the high initial cost for power-plant installations."

These important facts do not harmonize with the claims which have been made about the economies to be effected by the general introduction of electrification.

There is another point which must be taken into consideration in connection with electrification projects. The residents of large cities have become accustomed to riding for considerable distances upon local electric railways for very moderate fares, usually, in the United States, the fare being five cents. There has thus grown up an association in the minds of the passengers of electric power and cheap transportation. It follows that when a steam railroad adopts multiple-unit electric trains for suburban service the public is apt to look for a reduction in the price of tickets, an expectation which is unreasonable. People generally do not consider that the interest on the cost of the installation must be paid, nor do they realize the difference between a railway company and a rapid-transit concern. These facts were well brought out by the discussion which recently took place in New York about commutation rates. These rates were much lower than the regular ones, and although the increase desired by the railroads would have raised them but slightly and still left them lower than any other, a storm of protest was raised against the increase, showing the popular feeling that the railways can afford to carry passengers below cost.

Returning to a consideration of the electric locomotive, Mr. Muhlfeld's experiences would indicate that such locomotives should not be employed except in cases in which their use is unavoidable. If, in the course of time, it is found that they can be of greater help in terminal work than at present, it will be necessary to evolve a design which will incorporate a moderate initial cost, simplicity and strength in construction, medium weight and speed, and maximum power. In this kind of service it is not so much speed that counts as it is rapid acceleration, since this assists greatly in the relief of a crowded terminal.

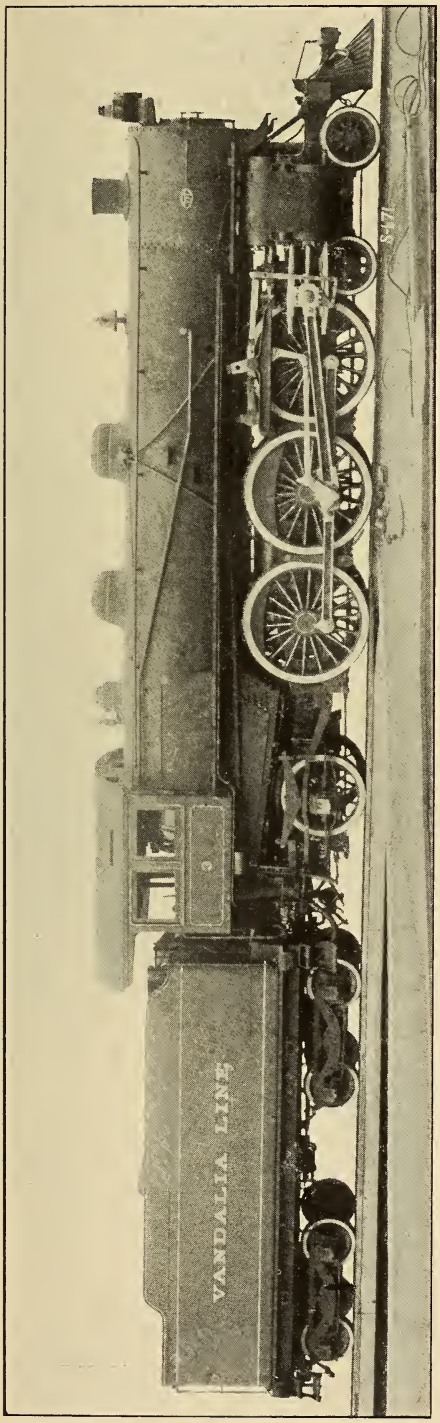
Notwithstanding the tendency to experiment with various designs, it seems that an electric locomotive having two four-wheeled trucks and concentrating its entire weight on the driving wheels should prove to be the most economical and satisfactory.



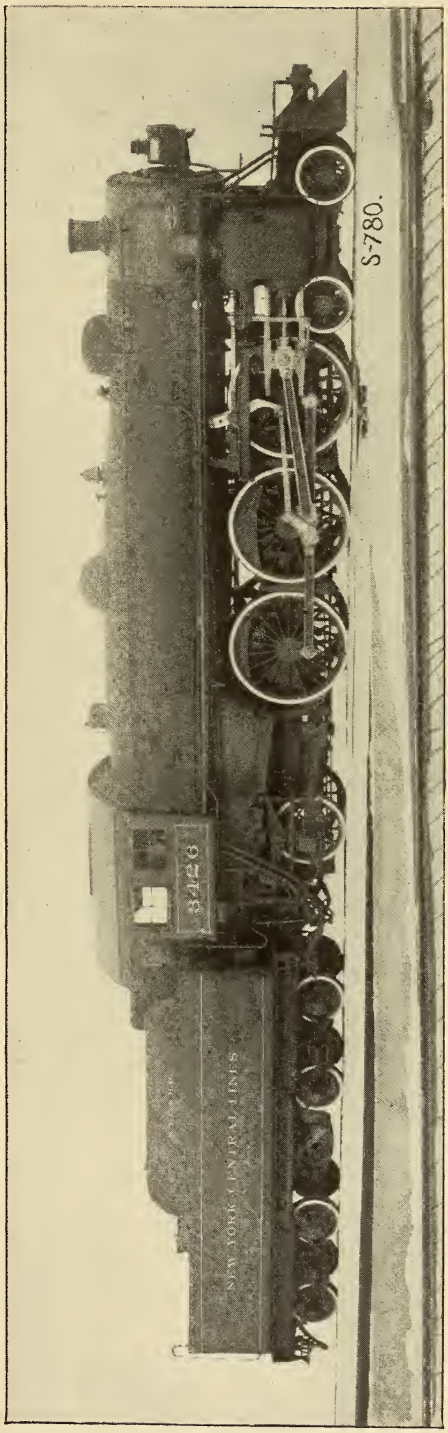
MALLET ARTICULATED LOCOMOTIVE FOR DULUTH, MISSABE AND NORTHERN RAILROAD. BALDWIN LOCOMOTIVE WORKS

That the electric locomotive will ever replace the steam locomotive in high-speed service is not considered probable by reliable authorities on the subject. In work of this kind the capacity for rapid acceleration is of no consequence compared with the supreme importance of being able to maintain a high velocity on long runs. The steam locomotive may not be able to reach its maximum speed as quickly as the electric locomotive, but when that speed is once attained the latter is out of the race.

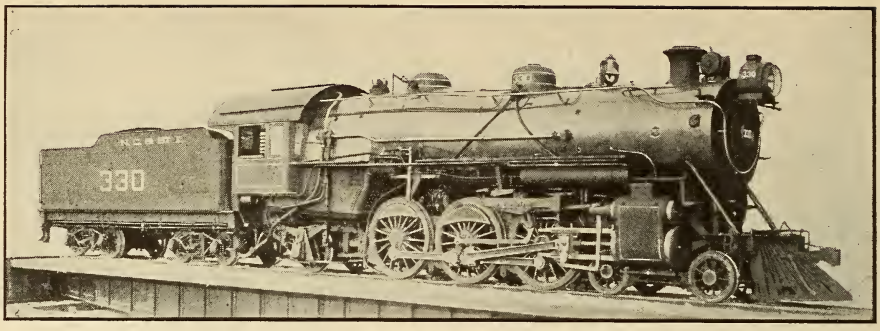
It would seem far more profitable for the electrical engineer to confine his activity to his legitimate field and refrain from attempting to enter a department of service already pro-



PACIFIC TYPE LOCOMOTIVE FOR THE VANDALIA LINE. THE AMERICAN LOCOMOTIVE COMPANY



NEW YORK CENTRAL CLASS K-3 PACIFIC TYPE LOCOMOTIVE, USED FOR HAULING THE TWENTIETH CENTURY LIMITED. THE AMERICAN LOCOMOTIVE CO., SCHENECTADY, N. Y.



PACIFIC TYPE LOCOMOTIVE FOR NASHVILLE, CHATTANOOGA AND ST. LOUIS RAILWAY. BALDWIN LOCOMOTIVE WORKS

vided for in an entirely satisfactory manner. The transportation problem provides ample opportunity, both in magnitude and variety, for the application of active effort, and in every instance the question under consideration should be decided upon its own merits without jumping at conclusions.

Some reference has been made to the conditions which must be met by the electric locomotive if its use is to become more extensive. It now becomes desirable to take up some points connected with the permanent way.

Obviously the power plants must be of substantial construction, for, although expensive, the permanence of such structures will warrant a fair outlay. If a third rail is used, care should be taken to make the work durable, and this should present no serious difficulties.

An overhead wire, however, is a different proposition. The use of steel bridges across the track for carrying wires is a rather costly method. It is necessary, however, to provide against the effects of severe storms, and if overhead wires are to be used they must be kept in place under all circumstances. The line difficulties, however, are not insurmountable; the great question appears in the power generating stations.

The equipment of a power house is a very expensive undertaking. In but few localities is water-power available, and in the majority of cases a steam generating plant is necessary. To this must be added a vast amount of costly apparatus for the regulation and distribution of the current in the quantity and manner required. It is here, then, that costs must be reduced. It has been repeatedly said that power plants are expensive and inefficient; and while this assertion may be too general and not wholly in accordance with the facts, it is certain that improvements must be made before railways can be induced to regard electrification more favourably. The cost of electrical equipment at the present time is little short of prohibitory, and it is in this matter that a change must come if electric power is to become available for railway service. There is no reason why a well-designed electric locomotive should break down if properly maintained and carefully handled. It is always possible, however, that the source of power may give out, and the consequences of the failure of current supply on a busy railroad are too serious to be permitted. Something must be done to provide against such a contingency. The safety of employees must also be considered and the probability of accident reduced to a minimum.

It has been maintained that in certain localities the handling of traffic by electric locomotives would be justified even though the cost should be greater than with steam. This proposition is not quite so unreasonable

GAS-ELECTRIC CAR FOR RAILWAY SERVICE. GENERAL ELECTRIC COMPANY

as it may appear, but its soundness depends upon a number of important factors. Before proceeding in accordance with this theory, however, it would be well to make further attempts in the direction of economy, as being of greater interest to the railways.

Taking up the subject of the multiple-unit train, it is even more difficult to make a correct estimate of the usefulness of the system than of the possibilities of the electric locomotive. This is due to the fact that there are several other ways of dealing with local passenger traffic. For example, it would be practicable, in many cases, to use small steam locomotives of special type in conjunction with light coaches frankly designed for the use of thrifty travelers, and, therefore, built as cheaply as possible; passengers who pay less than a cent a mile cannot expect to ride in Pullman cars. Again, if the traffic is not too heavy, there is no reason why gas-electric cars, of the type developed by the General Electric Company, would not answer the purpose.

If, however, the multiple-unit system is to be used and the cost of installation cannot be reduced, then the traveling public should expect to pay for the privilege in the form of increased rates. There is nothing unreasonable about this position, since there is no more reason why the railroads should sell transportation at a loss than that merchants should dispose of their goods below cost.

In this connection it should be remembered that a number of steam railways do not pretend or desire to handle suburban business, and are interested only in the "long haul," both passenger and freight. From this point of view reference may be made to the fact that some men, who have given much thought and study to the problems connected with urban transit, believe that the handling of local passenger traffic is not properly a function of the great railway systems at all. The railways themselves have often denounced such traffic as unprofitable, and consider it more of a nuisance than anything else. It has been suggested that there should be a segregation of through and local passenger traffic by providing electrically-operated rapid transit lines, radiating in all directions, and affording transportation from any subway station to points 40 or 50 miles away, and thus forming an extension of the local transport system to all the suburban points tributary to a city without change of cars. Under such a system no terminals would be required, and the passengers would be able to alight at points of their own selection without being carried to some arbitrarily selected point in which they were not interested. Such an arrangement would be of great benefit to suburban residents, and would leave to the steam railways the legitimate business of running long-distance, high-speed passenger trains and heavy merchandise transport. While such a plan is necessarily in the future, it is not improbable that it will some day form a part of the transport equipment of many large cities.

One of the strongest features of the above plan lies in the segregation of the through and local passenger traffic. Passengers who ride in Pullman cars at speeds of 60 to 90 miles an hour pay well for the comfort and speed which they enjoy, and are entitled to special consideration, including freedom from the discomfort of the crowding and confusion of the local service. In any case, people having very diverse objective points should not be forced into that contact which necessarily leads to confusion.

Whatever may be the cost, there must, in the future, be some change in the methods of handling passengers in large centres of population, and in this work electricity will be required, regardless of increased expense.

In all that has been said about electrification there has been an effort to treat the subject with fairness. Of course, there is certain to be a difference of opinion as to just what constitutes fairness. Electrical engineers believe, and with reason, that they are offering one of the greatest achievements of the age for the serious consideration of the railways. In the past, however, they have sometimes been led by their enthusiasm to advocate plans which could not command the acceptance of practical men. More recently, however, there has been developed a tendency on both sides to view matters calmly, to the manifest advantage of real progress.

As the statement has been made above that the electric locomotive will not supplant the steam locomotive for high-speed service, it might be well, before concluding, to give some idea of what a good steam locomotive really can do, and, consequently, of what an electric locomotive will have to do, to meet the case.

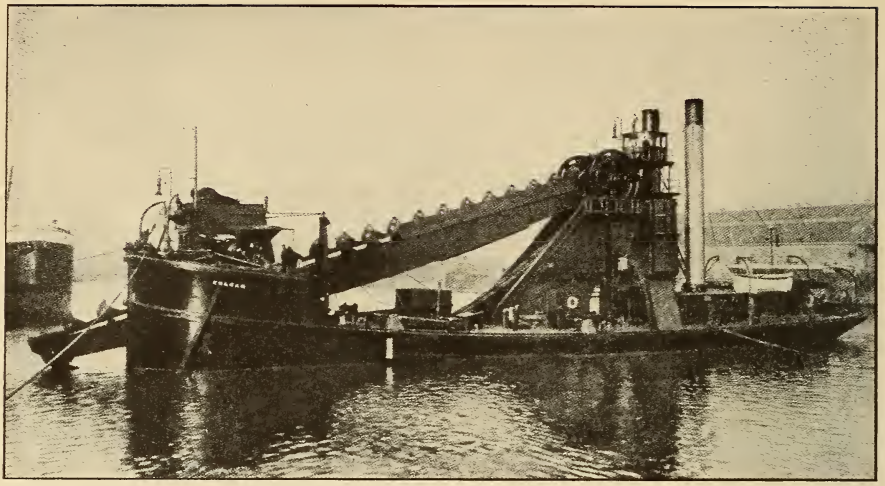
The new Class K-3 Pacific type locomotive, on the Lake Shore & Michigan Southern Railroad, is capable of hauling eleven steel cars, weighing 810 tons, at an average speed of more than 68 miles per hour. This is done as a matter of regular performance. The Class K-3 is a simple engine fitted with a superheater. The New York Central & Hudson River Railroad owns a similar class, and one of these engines ran for three consecutive miles at a speed of 100 miles per hour. These splendid engines were built by the American Locomotive Company. They are handling every day, regardless of weather conditions, trains weighing from 700 to 850 tons. Any comparisons, however, will have to be left in abeyance until a length equivalent of a railway division of about 140 miles is equipped with electricity, and this is about double the distance which will be covered by the New York, New Haven & Hartford Railroad between New York and New Haven.

HARBOUR DREDGING

By Brysson Cunningham

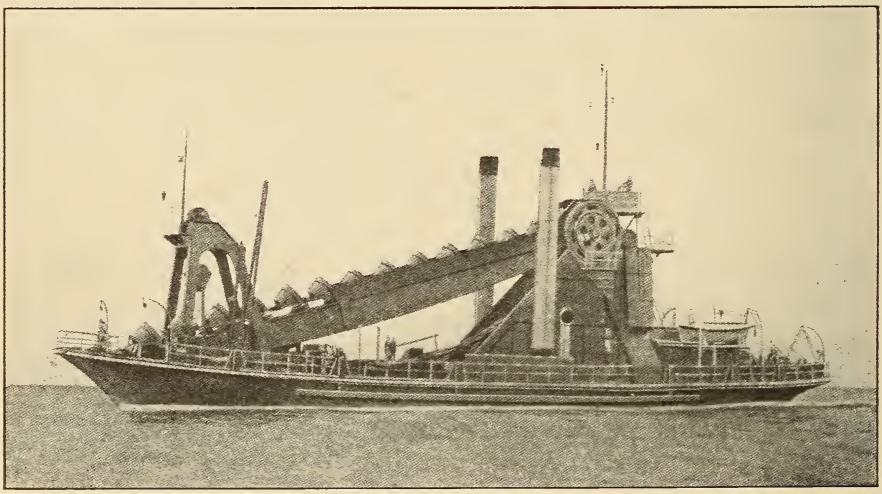
IT will scarcely be gainsaid by anyone with a knowledge of the subject that the most characteristically outstanding feature of port maintenance and improvement work for the past ten or fifteen years has been (and is especially so at the present day) the operation of dredging. There is scarcely a harbour of any commercial importance where appliances for the deepening of the entrance channel and for the maintenance of the fairway are not in constant and energetic service. Natural draught commensurate with the needs of modern vessels is rarely obtainable at the termini of existing sea trade routes, and the insistent and ever-increasing demands of naval architects and shipbuilders render it imperative on the part of harbour authorities to secure, by artificial means, every additional foot of depth of water which can be achieved within the limits of expenditure, governed only by the financial resources of the locality. Vast sums of money are annually devoted to the installation and augmentation of dredging fleets, and enormous quantities of material are annually raised and removed by this means. Within the last two years the port of London has seen its dredging equipment doubled in capacity, at a cost of nearly half a million sterling; while from the entrance to the port of Liverpool upwards of 160 million tons of sand have been dredged during the last twenty years, the present rate of progress being nearly 20 million tons per annum. To form some realistic mental conception of what is meant by figures of this magnitude, let us say that if we assume the material dredged to be able to stand naturally at a slope of 2 to 1, or 26½ degrees, the 160 million tons would form a conical mound twice as high as the Great Pyramid of Egypt, or two and a half times as high as the great cross of St. Paul's Cathedral; and that the area of its base would be more than 300 acres—say equal to the area of Hampstead Heath, or more than three times that of St. James Park. Illustrations such as these might be given almost indefinitely, but the foregoing will suffice to show the enormous masses of alluvium and detritus which are being dealt with, and what an extensive field of operations in this direction lies open to engineering enterprise. There is no present indication of any relaxation of effort; on the contrary, dredging programmes are being extended and developed, and a more rapid rate of execution is being sought, and, as a natural sequel, obtained.

If one were asked to name the most novel and conspicuous feature of recent years in regard to dredging work, there can be little doubt that the proper reply would be the advent and growing use of the suction cutter. This appliance, now used in connection with material of the most diverse and intractable character, is the outcome of the ordinary suction pipe used so successfully for the removal of arenaceous deposits. The expedition with which huge quantities of sand could be drawn up an inclined tube by the agency of the centrifugal pump led to the consideration that, if other material could be broken up and comminuted to a sufficient extent, the hydraulic method



TWIN-SCREW BARGE-LOADING BUCKET-DREDGER DON FEDERICO, BUILT BY FERGUSON BROS., RENFREW, SCOTLAND, FOR THE BUENOS AIRES AND PACIFIC RAILWAY COMPANY

of removal would be equally applicable. And this, indeed, proved to be the case. Revolving cutter blades were introduced at the entrance to the suction pipe, and when these were actuated by suitable gearing the nozzle worked its way through the solid mass, disintegrating it and enabling it to be carried in suspension by the volume of water sucked through the orifice to the suction pump. There was little difficulty in dealing in this way with earth of a marly, or brittle, nature, easily resolvable into disconnected particles. The real trouble was experienced in dealing with clay and argillaceous matter, which persisted in clogging the cutters and choking the intake. For a time it seemed as if the difficulty would be insuperable, but persistency of effort and numerous experiments eventually showed that it was simply a question of the form of the cutter blades; and when these were designed to the right shape and pitch the effective-



SELF-PROPELLING BARGE-LOADING BUCKET DREDGER CREWE, BUILT BY FERGUSON BROS. FOR THE LONDON AND NORTH WESTERN RAILWAY COMPANY

ness of the machine was placed beyond dispute.

Here are a few instances, taken almost at random from the columns of the technical press, of the capabilities and performances of the modern suction cutter dredger: A dredger recently constructed for the service of the South Australian Government has exceeded, on trial, the contracted output of 1,000 cubic yards of stiff clay per hour, which is dredged from a depth of 43 feet, raised to a height of 20 feet above waterline, and then forced through 1,500 feet of discharge pipe, 28 inches in diameter.[1] The records of the work carried out in connection with the deepening of the New York State Barge Canal show that in September-October last year, during a period of thirty-one days, 248,473 cubic yards were removed by a 20-inch suction cutter dredger—an average of more than 8,000 cubic yards per twenty-four hours. The possible working time was 744 hours; the actual time, 578 1/3 hours, giving 430 cubic yards per hour as the actual rate of output. The material at first was coarse gravel, with numerous roots, logs and stumps embedded in it; changing first to loam, containing a few roots, and, finally, to hard blue and yellow clay. The height of lift averaged 18 feet, and the length of discharge pipe line was from 850 to 1,200 feet.[2]

An even more important instance is that of the performance of the *Junja* (one of two similar dredgers—the other is the *Kalu*—constructed for the port of Bombay). During one week's working this vessel dredged and discharged blue clay at the average rate of 2,700 cubic yards per hour and cut out a channel 300 feet wide, with a depth of cut of 21 feet and a length of 1,000 feet, in less than 85 actual working hours. During the operation it is recorded, moreover, that a considerable quantity of quarried stone was encountered, many of the pieces weighing more than 400 pounds apiece. These were raised and discharged through a pipe line 4,500 feet long without any trouble.[3] This approximates very closely to the record of the *J. Israel Tarte* on the St. Lawrence in September, 1903, when, in twenty-six working days, the output of blue clay is stated to have been 757,100 cubic yards dredged from a depth of 35 feet and delivered through a line of 2,000 feet.

These dredgers, to which may be added the *St. Lawrence*, launched in September of last year, and the *Labrus*, in May of this year, each of 2,000 tons capacity, are probably among the largest and most powerful vessels of the type in existence at the present time. It would be idle, however, to contend that they represent anything like the last word in suction cutter-dredger construction. The plain suction dredger for sand has reached a capacity for raising over 10,000 tons per hour, and there is every likelihood of the cutter appliance following rapidly in its wake.

The sand pump, or suction dredger, in fact, merits a word in passing. Though not so omnivorous as the cutter dredger, it is, nevertheless, an invaluable implement for its purpose. The record of 10,000 tons loaded in 50 minutes as an everyday working rate is held by the *Leviathan*, a vessel constructed in 1909 for the Mersey Docks and Harbour Board. She is fitted with suction pumps 42 inches in diameter, and fills into her own hopper compartments through four suction pipes from a depth of 70 feet below the surface of the water. Her dimensions are 469 feet long, 69¾ feet beam and 32 feet deep. At work on the bar at the entrance to the River Mersey, she pumps up over 12 million tons of sand per annum.

The removal of rock is not yet within the range of capability of the suction cutter, and for this work there is a very effective tool of a to-

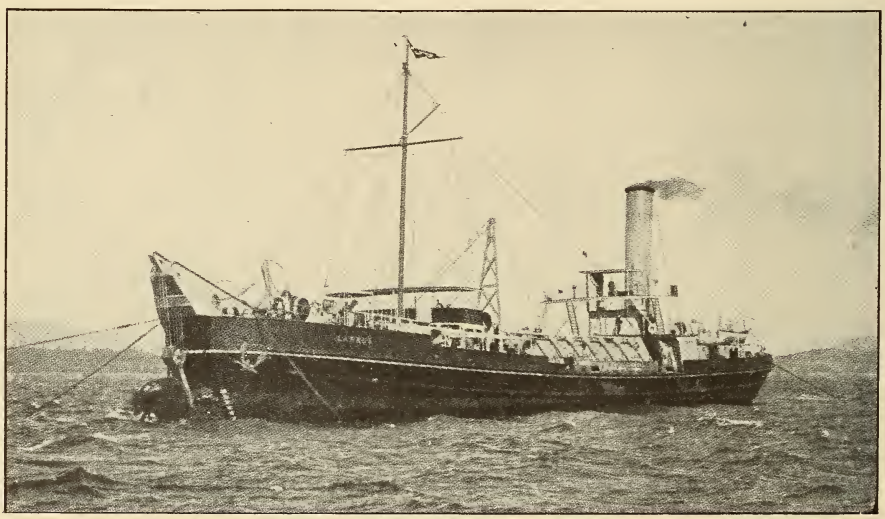
[1] Vide *Engineer*, Sept. 1, 1911.

[2] Vide *Engineer*, Sept. 22, 1911.

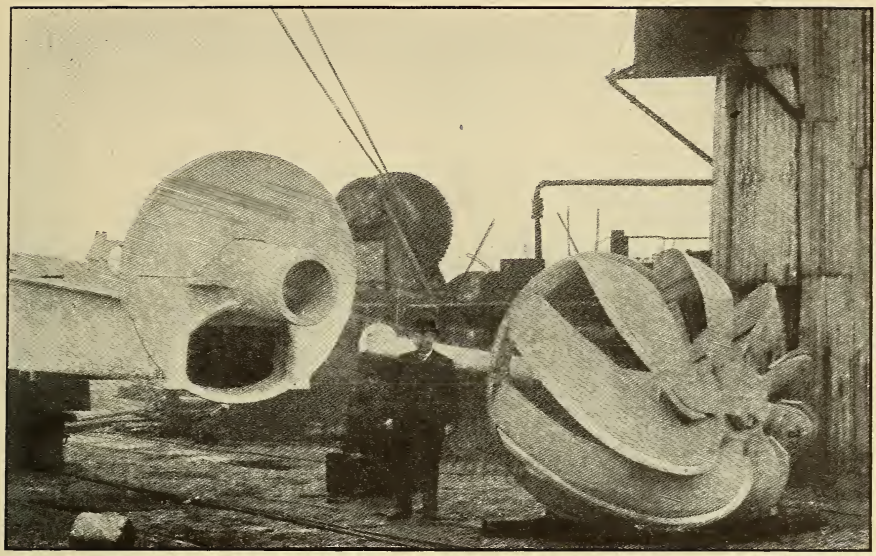
[3] Vide *Engineering* Sept. 3, 1909.

SUCTION CUTTER DREDGER ST. LAWRENCE, CONSTRUCTED BY WM. SIMONS & CO., LTD., RENFREW, SCOTLAND, FOR BRITISH ADMIRALTY

tally different type. The idea of shattering rock under water by means of the fall of a heavy ram appears to have originated in France something like half a century ago, but the modern rock cutter represents a very marked advance upon its prototype of that date. As at first tried on the Suez Canal, the rams, or pointed chisels, were only 3½ tons weight. These were afterwards increased to 13 tons, and now they are being constructed to 20 and 22 tons. The usual weight, however, lies between 12 and 15 tons, and rams of this size are employed on every variety of rock, ranging from soft sandstone to the most adamantine granite. The cutters are furnished with renewable points, conical in shape, of hard chrome steel. A drop of 6 to 10 feet is generally sufficient to produce disintegration, and the blows can be repeated with effect until a depth of 3 feet is obtained, when it becomes desirable to dredge the site before continuing breaking operations. It is found that the average result in hard rock is 2 cubic feet per blow, and that 150 blows can be given per hour.



PATENT SUCTION HOPPER DREDGER LABRUS, BUILT BY W. SIMONS & CO. FOR THE UNION GOVERNMENT OF SOUTH AFRICA. (PORT NATAL.)

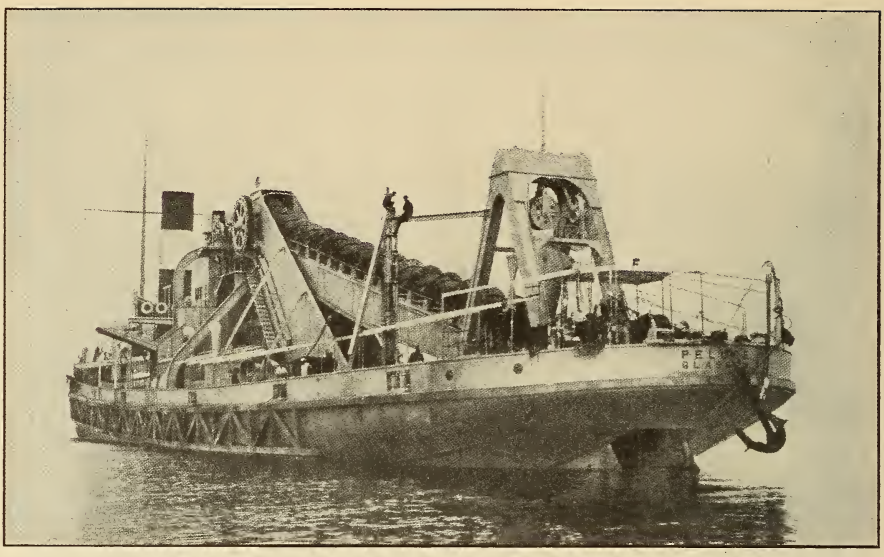


DETAIL VIEW OF CUTTER FOR SUCTION DREDGER, BUILT BY LOBNITZ & CO., LTD., RENFREW, SCOTLAND, FOR THE SUDAN GOVERNMENT AND THE SUEZ CANAL COMPANY

This is equivalent to about 10 cubic yards per hour for a single cutter machine; and about 50 per cent. more work will be achieved by the use of a double cutter. Writing in 1907 of a Lobnitz double cutter apparatus, which had been at work since 1902, M. Quellenec, consulting engineer to the Suez Canal Company, said: "On the average, 132 blows are delivered per hour of effective rock breaking; but allowing for stoppages, for repairs and drawing to one side to leave the waterway clear, 83 blows are delivered by the ram per hour of work paid to the crew. In the Suez Canal about 30 per cent. of the time is lost in drawing to one side to allow ships to pass. In rock breaking with rams under ordinary conditions, it may be reckoned that about 115 blows could be delivered per hour paid-for work. The average thickness of the bed of rock shattered is 2 feet 7½ inches, and, under the conditions prevailing, the number of blows required for the shattering of a cubic metre varies from 1 to 40; but 40 blows is a maximum very rarely reached, and the mean is 7.1 blows per cubic metre, equivalent to 5.4 blows per cubic yard of rock shattered."[4] The rock was very variable in composition, consisting of limestone, calcareous agglomerates, generally containing shells, calcareous tufa, gypsum and alabaster. At Blyth, where the rock is a sandstone, ranging in hardness from mere friability to a resistance equal to that of basalt, Mr. Sandeman records that a Lobnitz ram of 15 tons weight, allowed to fall from a height of 8 feet, penetrated the rock to a depth of 3 feet on an average of 8 or 9 blows, which was sufficient to allow of the material being dredged to a depth of 2 feet 6 inches. The ram was at first worked at distances apart of 3 feet, afterwards increased to 4 feet 6 inches, which was found suitable for either hard or soft rock.[5]

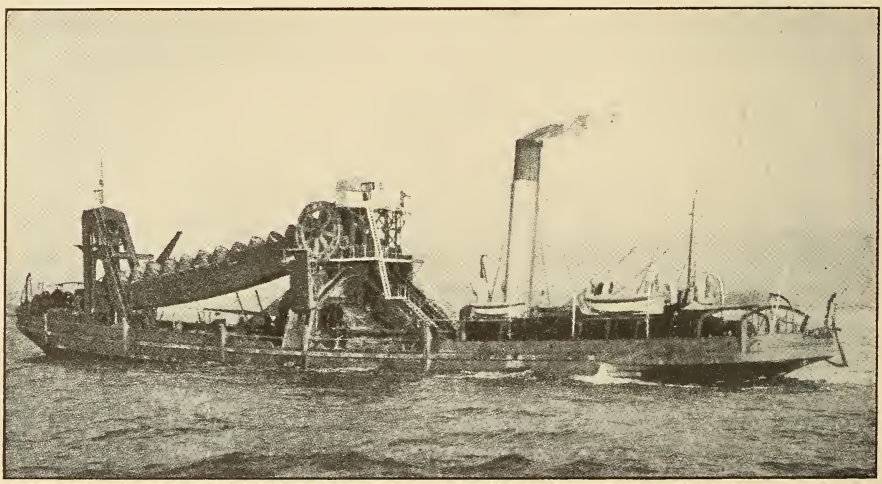
The suction pump, the suction cutter and the rock breaker certainly cover in their respective departments the whole range of materials met with in the known course of dredging operations. And there is one engineering appliance of greater seniority than any of these, which is

[4] Engineering Conference, London, 1907.
[5] Ibid.

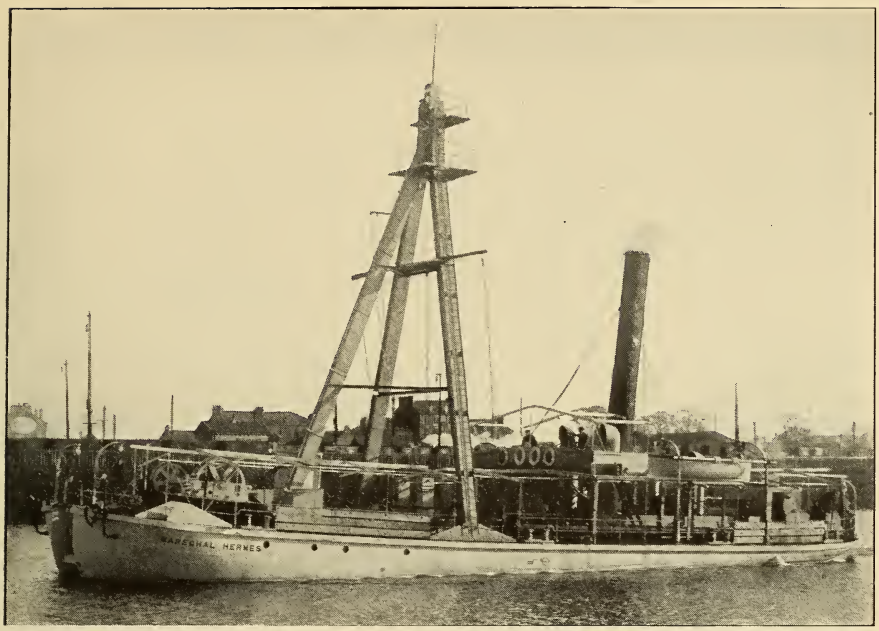


LARGEST BRITISH BUCKET DREDGER AFLOAT, CONSTRUCTED BY LOBNITZ & CO. FOR THE SUEZ CANAL CO.

capable of combining the functions of each of them, and performing these functions, too, in an eminently satisfactory manner. This maid-of-all-work is the bucket dredger, which disdains no mud as too soft, picks up clay, gravel, and even boulders, with ease, and is not deterred by rock of the less indurated varieties. For all-round work, in fact, there is nothing to beat the bucket dredger. In America it usually takes the form of a single scoop of 5 or 10 cubic yards, or ever greater capacity, fixed at the end of a long operating arm or lever, and is there known as the dipper dredge. In Great Britain the adopted form is that of an endless chain of buckets revolving about two rotating tumblers within a frame, which is called the ladder, the dredger being known as the ladder dredger. This last has been responsible for most of the heavy dredging which has been done at British and Continental ports. The capacity of the

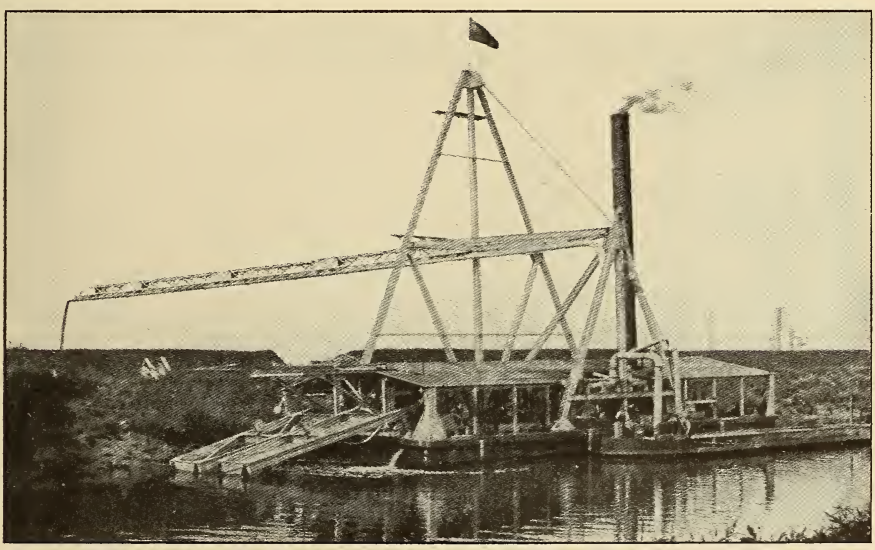


POWERFUL BUCKET HOPPER DREDGER, BUILT BY LOBNITZ & CO. FOR THE NORTH EASTERN RAILWAY CO.



DREDGER MARECHAL HERMES, BUILT BY LOBNITZ & CO., SCOTLAND

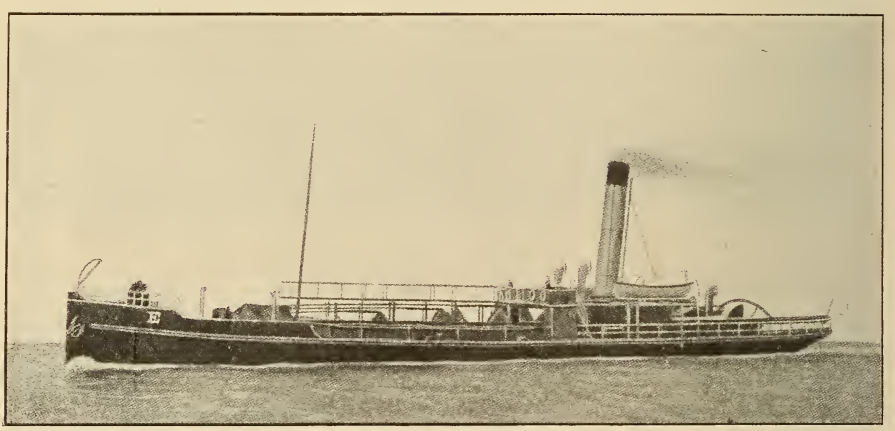
buckets ranges from 5 to 55 cubic feet, but generally about 35 cubic feet is looked upon as the useful maximum. The output, of course, varies considerably with the material dealt with; but moderate-sized dredgers are accustomed to raise 400 to 500 tons of stiff clay and the more powerful craft can remove up to 1,000 tons per hour. The vessel *Vulcan*, belonging to the Mersey Docks and Harbour Board, may be taken as an example of the class. She is a self-propelling, centre-ladder



LONGSHOOT SUCTION DREDGER, BUILT BY LOBNITZ & CO., FOR THE MANCHESTER CANAL CO.

dredger, 181.3 feet long, 41.1 feet beam and 12.3 feet deep, capable of working to a depth of 55 feet below water level and of cutting her flotation in advance. The buckets have a capacity of 20 cubic feet, and travel at speeds of 12 or 20 feet per minute, according to the nature of the work. Two bucket dredgers recently constructed for the Port of London Authority, with 27 cubic foot buckets, are capable of dredging at the rate of 765 cubic yards per hour when working at a depth of 55 feet.

The more intractable the material, the more the bucket dredger seems to assert its serviceability; and if there is to be found in any respect a flaw in the dredger's merits, it can only be in regard to its less successful manipulation of that flocculent silt which is the bane of tidal harbours. This impalpable stuff, deposited as lightly as dust on a chimney piece, is so rapidly taken up into suspension by any movement of the water in which it lies that it is a most difficult proceeding to prevent



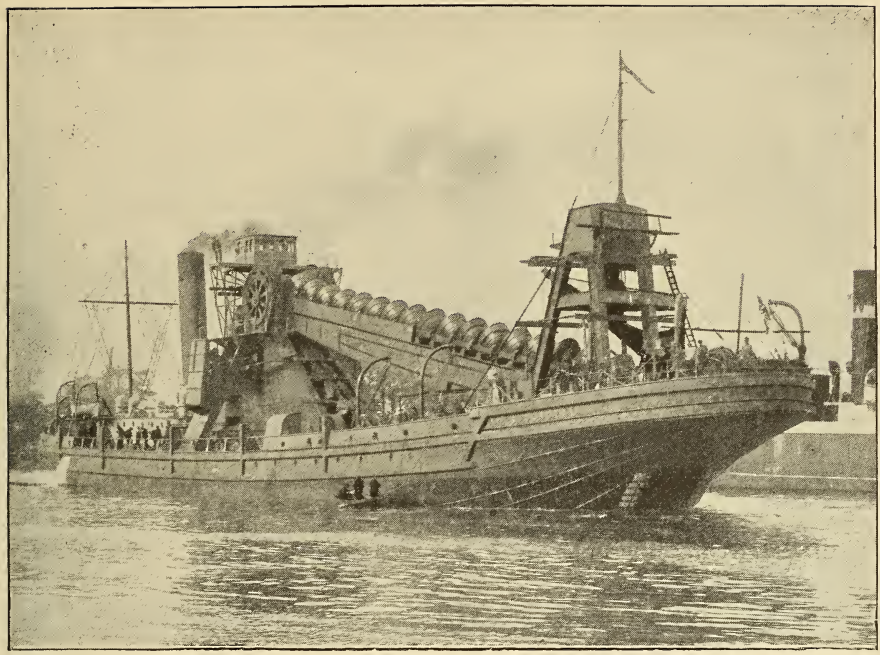
TWIN SCREW HOPPER BARGE "E," BUILT BY FERGUSON BROTHERS, SCOTLAND

As to the adaptability of the bucket dredgers to all classes of material and its utility under extremely trying conditions, the following evidence of the character of the work carried on in the River Tees is a striking tribute. During a period of twelve months 417,963 cubic yards were dredged at a net cost of £22,-432. About two-thirds of this total was in very hard boulder clay, and there were removed therefrom, chiefly from the workings of the dredgers, 1,651 stones, varying in weight from 5 cwts. to 4 tons apiece; also, 19 tree trunks, varying in length from 10 to 20 feet; 16 tree roots and stumps, and 107 miscellaneous obstructions. Of the total of 1,651 stones, 1,523 were raised by the dredgers without the aid of divers.[6]

[6] Vide *Engineer*, June 16, 1911.

it escaping from the bucket which collects it, as the heavy, unwieldy frame sweeps through the mass, and equally difficult to confine it in the hopper which receives it.

The best means of dealing with material of this character is by means of the grab bucket. It is rarely that work involving the removal of silt is other than that associated with the maintenance of depth in closed basins or sheltered recesses, where there is sufficient stagnation to permit of its deposit. And here the grab proves its great advantage over other types of dredger. It is handy and compact, easily workable in confined situations, rapid in action, and, above all, it succeeds in entrapping the mud with the least admixture of water and the least disturbance of its consistency. But the grab does



BUCKET HOPPER DREDGER COROZAL, BUILT BY WM. SIMONS & CO. FOR ISTHMIAN CANAL GOVERNMENT

not stop at this point; for anyone with experience in dock dredging will recall how it picks up indiscriminately and indifferently a multitude of articles which, somehow or other, in spite of prohibitions and regulations, find their way to the bottom of a dock—coal in lumps and in mass, hoop iron, logs of hardwood, railway metals, cargo trolleys, bags, bales and barrels of miscellaneous content, pigs of iron and lead, and a hundred other things, some of them repulsive and gruesome in the extreme. All these are picked up by the grab with the same indifference and regularity as that which characterizes its work in more appropriate material.

There are some excellent exam-

TRAILING SUCTION DREDGER M. O. P. "210 C," BUILT BY WM. SIMONS & CO. FOR ARGENTINE GOVERNMENT

ples of this appliance at work in the Liverpool docks. The grabs are mounted on barges of 1,100 to 1,400 tons hopper capacity—four cranes to the barge, two on the starboard and two on the port side. The buckets have a capacity of 70 cubic feet, and they can dredge, if necessary, to a depth of 55 feet below water level. They deal with nearly 2½ million cubic yards per annum, at a cost which is considerably less than if the work had been done by bucket dredgers.

This brief sketch of recent progress in harbour dredging appliances would hardly be complete in range (it cannot pretend to completeness in any other sense) were no allusion made to the vessels which receive the dredged materials for conveyance to a depositing ground. In many cases the hopper and the dredger form a single craft, but the interruption of operations for long periods while such a vessel is traveling to and from the depositing ground render it much more advantageous in large undertakings to maintain an independent fleet of hopper barges, which are loaded and despatched in turn, keeping the dredging plant fully employed. These hopper barges have capacities ranging up to 1,500 or 1,600 tons, and are capable of steaming at speeds of 10 to 12 knots. The hopper is placed amidships, being formed of bulkheads, one at each end and one inclined at each side, running fore and aft. There is a buoyancy space on both sides of the hopper. The crew are accommodated forward, and the machinery is placed aft. The hopper doors, which are of steel plating lined with elm, are raised and lowered by winches, arranged at each end of the hopper, and provided with chain barrels corresponding to the number of pairs of hopper doors.

That there is scope for development in harbour dredging appliances will not be denied. Powerful and effective as are the machines now in use, there are possibilities of more efficient working and of increased output which will, sooner or later, be realized.

With the expansion of operations in the immediate future the necessity is already apparent, and it will, no doubt, be met as satisfactorily as have been the requirements of the past.

THE SELECTION OF ELECTRICAL APPARATUS

By H. M. Phillips

II.—CONDITIONS GOVERNING EFFICIENCY

In the February issue of this magazine, Mr. Phillips discussed at some length the considerations which should be taken into account in the selection of electrical machinery, with especial reference to the conditions governing capacity. The present article effectively supplements the former one by examining the conditions governing the efficiency of the apparatus purchased, taking into account not only the technical point of view, but also the practical and commercial conditions which are often of controlling importance. Taken together, the two articles form a discussion of the subject which may well be read by anyone who is intending to purchase electrical equipment for either power or lighting purposes, as indicating to him in clear and non-technical language the principles which should be borne in mind before making a decision.—The Editor.

USING the term in its broader sense, both the business man and the engineer are striving for the greatest possible efficiency in everything that goes toward the making up of a business or of an engineering proposition. In most cases it can finally be resolved to a matter of dollars and cents, the aim being to get the maximum return on the capital invested, not necessarily from day to day, but over a period covering a reasonable number of years. The fact that the available capital is generally limited will frequently have an important bearing on this efficiency; manufacturers are offering two machines, one of which turns out the work considerably cheaper than the other, but the machine itself costs twice as much, which cost will be saved in a comparatively short period of operation. One manufacturer selects the cheaper machine, but buys two of them, which will give him a greater output and larger net profit; another may take the cheaper machine on account of the saving in floor space; the more expensive machine takes up too much room, the other leaves available space that he can utilize to a greater profit than the saving effected by the larger machine. A third fully appreciates the advantages of the higher-priced machine, but knows that the additional money required to purchase it will yield a higher return in some other part of his plant. A fourth finds that the high-priced machine is exactly suited to his plant, purchases it, and has a very satisfactory investment. Each of these men has solved correctly the problem of maximum efficiency for the conditions with which he is confronted; in three cases out of the four the machine with the lower operating cost—the more efficient machine from the engineering standpoint—was rejected.

In the present article "efficiency" will be used, in its more restricted and technical sense, to denote the percentage of the power received which a machine is able to deliver for useful purposes; in other words, the output divided by the input, each of which quantities being expressed in power units instead of dollars. An attempt will be made to show the reader to what extent high efficiency is beneficial and desirable, on the dollar basis, in his individual case. It must be confessed that comparatively little apparatus is purchased in the logical manner described in the preceding paragraph; at present, however, we are dealing with electrical matters only; we find a few purchasers who use the highest-priced apparatus only; arguing that it must necessarily be the best, and that the best is always the cheapest, they are more nearly correct than many others, but will in some cases be wasting their money. With a far

more numerous class low price appears to be the only consideration, with, perhaps, a few makers of extremely cheap apparatus stricken from the list of bidders. Many other considerations, such as personal or business friendship, the example of others, etc., influence some purchasers, but the question of efficiency is given little consideration. In buying an engine, guarantees of steam economy are usually considered, and tests may be conducted to insure that they are complied with. In the case of the modern direct-connected unit the generator economy may be included with that of the engine, so many pounds of steam per kilowatt-hour, but here the purchaser's quest for economy is likely to end; it does not include the motors that the generator is to drive. Whether an individual small motor has an efficiency of 80 or 85 per cent. may seem a small matter, but in the modern manufacturing plant the load on the generator is likely to consist largely of small motors. Is it not as well to save 5 per cent. of the steam consumption by reducing the working load as to obtain the same result by the use of a highly efficient engine? On the other hand, it will not pay to increase the investment more than a certain amount in order to effect this saving.

As a simple illustration we will take the case of a 10 horse-power motor driving a blower which requires the full 10 horse-power and is operated for ten hours per day for 300 days in the year. Current is obtained from a power company, measured by meter, and costs 8 cents per kilowatt-hour. The 10 horse-power output, reduced to electrical terms, becomes 10×746, or 7,460 watts, which is commonly expressed as 7.46 kilowatts. If the motor has an efficiency of 85 per cent., its input will be $7.46 \div 0.85$, or 8.78 kilowatts, and the yearly power bill will be $8.78 \times 10 \times 300 \times \$0.08$, which is $2,107.20. If the motor has but 80 per cent. efficiency, its input becomes $7.46 \div 0.8$, or 9.325 kilowatts, and the yearly bill is increased to $2,238. The more efficient motor shows a clean saving of $131.20 per year, which is certainly worth considering. To be sure, 8 cents is a pretty stiff price for power, and if we reduce this to 4 cents the saving is but half as much; but we would still be willing to pay considerably more for the first motor than for the second. Let us further suppose that the motor is to be run but one hour per day; the saving is now only $6.56 per year. What is it worth to effect this saving? There are some who will say that 20 per cent. is pretty big interest, and will give the more efficient motor a preference of $32.80. They may be right, but the question is worthy of consideration. Buying machinery is not quite the same as putting money in the bank; within a comparatively short time we must count upon losing the greater part of the principal. On the 20 per cent. basis it will take the motor five years to pay back this sum, without interest, and many things may happen in the meantime. The cost of power may be materially reduced, the motor may lie idle for a considerable period, it may be discarded for a number of different causes, and second-hand motors bring comparatively small prices. In spite of the rapid advance in electrical matters, there is no great danger of being compelled to abandon the present-day motor in favour of a more up-to-date model; it will probably last as long as the blower or other machine to which it is connected; but there are very few machines that continue in service for the original purchaser for a ten-year period. If not worn out, they are replaced by others of larger capacity or improved design, or else new conditions arise which render their use unnecessary. The purchaser must estimate, to the best of his ability, the number of years that the annual saving will continue before he can form an intelligent estimate of its value.

Next, suppose that the purchaser operates his own power plant. It is

to be hoped that he knows just what his power costs, including interest on investment, supplies, depreciation and repairs, fuel and attendance; it is likely to be between 2 and 3 cents per kilowatt-hour, although it may be considerably greater. The cost of fuel alone may be roughly taken at half this amount. With the two motors under consideration there is a difference of 0.545 kilowatt in the power called for, but this difference has an immediate effect upon the coal bill only. Some may say that the saving in coal due to so small a difference in power could never be detected; this is very probably true. It may be lost among variations of greater magnitude, but it is there, nevertheless, and should, therefore, be counted on. As the more efficient motor effects an immediate saving in coal only, there may be good grounds to consider that alone when the money value of its efficiency is estimated. There is, however, another point of view. If we pursue a modern system of accounting, the power consumed by the motor will be charged to the job it performs, and in making this charge we will figure the full cost of the kilowatts used, as is done with the other motors in the plant, and the cost of production will be affected accordingly. It is true that this will be a matter of bookkeeping rather than actual money value to the plant as a whole; for in the long run the amount charged to this motor will react on all the others; the more power taken from the plant, the less will be the cost per kilowatt-hour. The fact that the power plant is pretty certain to become overloaded eventually is a stronger argument for figuring the saving on the total cost per kilowatt-hour. There seems to be no limit to the growth of the demand for power; the central station supplying the general public always may be expected to grow by acquiring new customers; however crowded the factory may be, there is always room for another machine somewhere; old machines are being replaced by new ones of greater capacity with a corresponding demand for power, and, if all goes well, the factory will ultimately be enlarged. Even the hotel, store or office building is apt to find the load on its plant increasing from year to year; increased illumination is called for, new uses are being found for motors, electric heating devices are being installed. Very few engineers will install a power plant without providing some means for increasing its capacity when the proper time arrives. One motor may be a small matter, but motors are added, one by one, until it is necessary to enlarge the plant. When that disagreeable moment arrives the owner may say: "If I had installed efficient motors I might have gone on for another year or more." With the enlarging of the plant there will be an increase in the fixed charges, and there is quite likely to be an increase in the cost of a kilowatt-hour until the enlarged plant is fairly well loaded. There remains no excuse for saying that the inefficient motor, purchased prior to the enlargement, is wasting only a little coal; the increased installation was made partially for its benefit, and it must bear its proportionate share of the cost. It is never too late to begin the study of power economy, but the proper time to do so is at the beginning; after it has become necessary to enlarge the plant, or after a generator has been burned out through overloading, the benefit that might have been derived from an earlier start is not fully realized.

When a motor is operated for a considerable part of the time on light load that fact must be given consideration in estimating the difference in value between an efficient and inefficient motor. If the efficiency were constant at all loads, the average load could be taken as a basis for figuring instead of the rated capacity of the motor; but a slight correction may be necessary on account of varying efficiency. When the motor is

running on no load it may take 10 per cent. of the power required at full load, and its efficiency, of course, is zero. It rises quite rapidly as load is applied, and will probably be within a few per cent. of its maximum value at half load; a point of maximum efficiency will generally be found somewhere between three-quarter load and 25 per cent. overload. The falling off from the maximum is very gradual at first, but becomes quite rapid on heavy overloads. As a rule, the value is fairly constant between three-quarter load and 25 per cent. overload. In ordinary practice we may apply the full-load efficiency to the average load without serious error, but if the motor is to run a large part of the time on very light loads such allowance as appears necessary must be made for that fact. Most manufacturers will furnish a curve plotted to show the efficiency of the motor at all loads. The shape of this curve is apt to vary with different manufacturers and with different sizes of the same make of motor; two motors that have the same efficiency on full load may show a very considerable difference on light loads.

In connection with an alternating current system it may be necessary to purchase transformers. In addition to a guarantee of efficiency, the manufacturer is required to specify the "core loss," sometimes termed "iron loss," and "copper loss" of his transformer, the sum of the two being the total loss of power when the transformer is operating on full load. The relative importance of the two losses depends upon the character of the service for which the transformer is to be used. The ordinary transformer is connected to the generating plant as long as the latter is in operation, very frequently twenty-four hours per day. On lighting service it usually carries its full load for from two to three hours only; when operating motors the full-load period may be extended up to the full twenty-four hours, depending upon the operation of the motors. In the latter case the full load efficiency, from which the total loss can readily be calculated, is sufficient for our needs; but in the former the "core loss," which remains constant through the twenty-four hours, is evidently of much more importance than the copper loss, which may be so small as to be negligible during the period of light load. The copper loss is usually considered greater than the core loss at full load, but varies with the square of the load upon the transformer, or, more correctly, with the square of the current taken from the transformer, which distinction is of some importance when "power factors" are to be considered. At three-quarter load it is but nine-sixteenths of the full-load value; at half load, one-quarter, and at one-quarter load the copper loss is but one-sixteenth of its full-load value. The sum of the two losses at any load added to the load will give the input of the transformer at that load; dividing the load (output) by the input will give the efficiency. It is usually easier, however, to deal directly with the losses, and from the total losses per year we may compare the value of different transformers.

Lighting economy, with many different types of light to choose from, is such a complicated subject that an expert should be consulted in order to get the best results; it can be treated but very briefly at the present time. It will generally pay to be very liberal with the amount of light furnished, but it may be wasted by being wrongly directed, and there is generally considerable room for economy in the manner in which the light is obtained. The 16 candle-power carbon filament lamp is still in common use, and may be purchased with a rating of from 40 to 64 watts per lamp. There is but little difference in first cost, and at first glance the saving by the use of the high efficiency, 40-watt, lamp appears very desirable. Unfortunately, the

high-efficiency lamp is necessarily short-lived, and renewals must be considered; it is also very sensitive to fluctuations in voltage, and will burn out in a very short time if the voltage rises slightly above the normal. In buying high-efficiency carbon filament lamps, or lamps of other types, for that matter, it is advisable to have an actual measurement made of some of the lot purchased; there are instances in which the manufacturer appears to be rather inaccurate in his rating. Where light is desired only in close proximity to the lamp, an 8 candle-power, taking but little more than half the power of the 16 candle-power, will frequently give entire satisfaction. Lamps of 32 or higher candle-power may be used to replace an equivalent number of lamps of lower candle-power, with a marked saving in total operating expense; they may, however, fail to give the desired distribution of light, except in cases in which the smaller lamps are used in clusters. Against the economy derived by using lamps of assorted candle-powers we have the troubles arising from carrying a mixed stock and from the fact that the majority of the men in the plant will do their best, or their worst, to obtain a lamp of maximum candle-power for their individual use; high candle-power lamps will mysteriously disappear from their proper positions.

By substituting tungsten for carbon filament lamps the power cost may be reduced 50 per cent. or more; their first cost is high, but unless power is reckoned very cheaply or the breakage is unduly high there will be a very decided saving in the end. The chief objection to their use is the fragility of the filament; when first introduced these lamps would break with a very slight jar. They are much tougher at the present time, and will stand ordinary service successfully, but are hardly equal to the rough usage to which a good many incandescent lamps are necessarily subjected. Various types of arc lamps show very high efficiency, and may be used to advantage for general illumination, provided that it is possible to suspend them at a sufficient elevation. Mercury vapour lamps are also highly efficient, but their uses are limited on account of the colour of the light.

The power lost in the cables running to the various centres of distribution and to individual pieces of apparatus seldom receives the attention which it deserves. If a short distance only is traversed it is customary to use the size of wire prescribed by the underwriters for the sake of safety; as the distance becomes greater the electrician calculates the "drop" or loss of voltage, and, if necessary, increases his wire to such a size as will reduce the drop to a figure considered necessary for the proper operation of the apparatus in question; this may vary between 3 and 10 per cent. of the total voltage on the line. Let us go a step further and figure on the actual value of the power lost in the conductors. The drop being figured at full load, the percentage of power lost will be the same as the drop while this load is being transmitted, and, like the copper loss of a transformer, it will vary with the square of the load. Suppose that the area of the conductors is doubled; one-half of the power previously lost will be saved, and, at the same time, the cost of installation will be about doubled where heavy conductors are used. With light cables, with which the cost of labour and supports is a considerable proportion of the total, the increase will not be so great. If this shows a satisfactory saving for the money invested the effect of a further increase may be tried; the limit will soon be reached. It may be interesting to note that when figured in this way the size of the conductor is not affected by the distance transmitted; therefore, on very long lines the drop will be the determining factor, and may call for a larger conductor than the present method of figuring, while on short lines we may find

economy in the use of a heavier conductor than is generally installed.

We can afford to be rather liberal in regard to the size of conductors running to centres of distribution; changes in individual pieces of apparatus do not affect the main conductors, except in regard to the load that they have to carry, and they may, therefore, be counted upon for much longer life than a motor; when properly installed inside a building, they may be considered a fixture that will only be discarded by a radical change in the purpose for which the building is used. The large conductor reduces the drop, which is always desirable from an operating standpoint; it allows for an increase in the load by the installation of additional apparatus. When overloaded it does not have to be replaced; it is necessary only to install additional conductors, and, when finally discarded, the material brings a fair price as scrap copper.

The question of generator and engine efficiency is handled in practically the same manner as the efficiency of motors; longer service, however, may generally be counted upon from the former than from an individual motor. The question is merely how much are we willing to invest in order to save a given amount of coal.

In cases in which alternating-current motors and alternating-current arc lamps are to be used the question of power factor is somewhat allied to that of efficiency. Two motors, each having an efficiency of 85 per cent., but different power factors—say 85 per cent. for the first and 80 per cent. for the second—will give the same power bill by wattmeter measurement, and if the power is brought by that method the question of power factor will be of little importance. The first, however, draws 6 per cent. less current from the system than the second; it does not affect the load on the engine, but does increase the ampere load on the generator and wiring system. The generator that can safely carry but 80 motors of the lower power factor can carry 85 of the higher. When transformers are used they are affected in the same way as the generator and draw a correspondingly higher current from the latter. A further argument in favour of the use of high power-factor apparatus lies in the fact that considerably better regulation will be obtained from transformers and generators by its use; which may be quite an important matter if high-class lighting service is desired.

We are now brought to the subject of regulation, which deserves some consideration in connection with the general efficiency of the plant. The regulation of a motor is generally considered to be the percentage variation in speed between full load and no load; with the shunt-wound, direct-current motor or the alternating-current induction motor, the types most frequently used, the value varies between 3 and 10 per cent. of the full-load speed, according to the design of the motor. Either of these figures should be sufficiently close for most purposes. We also have a variation of speed, varying between about the same limits, on account of the heating of the fields of the shunt-wound, direct-current motor, which variation is much more serious in its effects on economy than the first, inasmuch as it occurs while the motor is running under a constant load. When the cold motor is started under its working load, assumed to be constant, its speed is below normal. During the first half-hour there is a considerable rise, and it continues to rise, with diminishing rapidity, for several hours, finally becoming constant at the rated speed of the motor. Many engineers consider that a rise of 10 per cent. in this manner is comparatively unimportant, and that figure is sometimes mentioned in specifications, although more frequently no mention is made of this feature. If the original speed of the motor is sufficient, it will be

running 10 per cent. faster than need be during the greater part of the day and increasing the power consumption above the needful amount by at least that percentage; or if the final speed is the correct one, the machines and the men dependent upon them will be working at reduced capacity during the early hours. As this variation in speed is due entirely to the temperature of the motor, it may be found that the motor runs considerably faster in hot weather than in cold, or the increase of 10 per cent. previously referred to may be raised to 12 or 13 per cent. on account of the rising temperature of the room in which the motor is operating. It is evident that for most purposes a motor with a guarantee not to increase its speed over 4 per cent. on account of heating is decidedly to be preferred to one that can only guarantee a change of less than 10 per cent. One of the advantages of the alternating-current induction motor is that there is hardly any variation of speed on account of temperature.

The multiple arc lamp is almost invariably used for indoor illumination and for a considerable portion of outdoor work, the series arc requiring a voltage that is generally considered too high for indoor use in connection with an illuminating system. These lamps are supposed to maintain a constant current—say 6 amperes—and manufacturers' specifications seldom allude to any variation from the specified amount; but it may be found that a certain make of lamp starts, freshly trimmed, at 6½ amperes, but falls to 5¾ when the carbons are nearly exhausted, the difference being due to the effect of the weight of the carbon upon the controlling mechanism of the lamp. If 6 amperes is the proper current, this lamp is wasting power during the first part of the life of a carbon and not giving proper illumination during the latter part. A lamp with controlling mechanism strong enough to hold the current within closer limits is decidedly to be preferred.

The regulation of a transformer is expressed by the percentage of rise in voltage when full-load current is reduced to no load, it being assumed that there is no change in the voltage of the line supplying current to the transformer. To insure the best lighting service the regulation should be as close—that is to say, the percentage as small—as possible. The regulation of any transformer will be found to be considerably closer when the load consists entirely of incandescent lamps, which gives a power factor of practically 100 per cent., than when a power factor of 80 or even 90 per cent. is introduced by the use of arc lamps and motors. It is, therefore, customary for the manufacturer to give a guarantee for regulation at 100 per cent. and at 80 per cent. power factor. It is difficult, if not impossible, to fix a definite money value on transformer regulation; it will almost invariably be found, however, that close regulation accompanies high efficiency.

Good regulation is also a very desirable feature in a generator, for the same reasons as with a transformer; but in this case it has little, if any, relation to the efficiency. The direct-current generator is almost invariably compound-wound, and with this type it is easy to adjust the winding, after the machine is completed, so that there will be practically no rise in voltage when full load is suddenly taken off the generator; occasionally this is all that the manufacturer guarantees. A generator may meet the guarantee in this respect, but fail to come back to the original voltage when the load is restored, which is of almost equal importance; this is a defect in design and not easily remedied. Again, both of these conditions may be met and there will still be intermediate points at which variations will be noted; the desirable feature is to have the voltage the same at all

loads, and whether load is being added or taken off of the generator. It is frequently desirable to have the voltage higher at full load than at no load, in order to make up for the drop in the wiring system. This is as easily arranged as it is to keep the voltage constant, but it is now desirable to have the increase in voltage perfectly uniform, proportional to the load at all times. Small alternating-current generators are frequently built so as to maintain regulation in a manner similar to the above; but with the larger sizes dependence is placed upon an automatic regulating device, which is distinct from the generator. In one sense the regulation of the generator is of less importance than that of the transformer; with the latter, poor regulation means that the voltage on the lamps will always be higher on light loads than on heavy, unless an attempt is made to compensate for the drop in the transformer by increasing the voltage on the lines supplying same when the load is heavy, which, for various reasons, is generally impracticable or only partially effective. When the generator fails to give the correct voltage the fact is soon noticed by the attendant, who makes it right by hand regulation. Common to both is the fact that when regulation is poor a sudden change in the load, such as is caused by starting or stopping a motor or by switching a considerable number of lights on or off, makes an equally sudden change in the brilliancy of the lights, which is, of course, annoying. A similar effect is produced by the drop in the wires leading from the generator to a centre of distribution, this drop, in fact, generally being greater than the regulation of the transformer. If there is but a single centre of distribution, the drop on the wires leading to it may be neutralized by the rise in generator voltage previously referred to; but as there are usually several centres, the drop in the wires leading to them will not all be the same, and some will be carrying heavy loads when others are not; an approximate compensation only is, therefore, possible.

It is decidedly difficult to get satisfactory generator regulation when an electric elevator comprises a considerable portion of the total load. The lights will flicker every time the elevator is started and stopped; the flicker may be but slight or otherwise, but such service is usually required in hotels, office buildings, or stores, and any irregularity in the lighting system is pretty sure to bring forth a vigorous protest. In purchasing a generator for such service the manufacturer should be informed of the operating conditions and asked for a guarantee covering momentary fluctuations of voltage under those conditions; if he can show a generator in actual operation and giving satisfactory service under conditions that are practically the same, there will be a better opportunity to judge of the results that may be expected and of his ability to make good his guarantee.

In order to be able to compare the merits of various makes of apparatus the manufacturers should be called upon to give definite guarantees covering all points that are considered to be of importance. Before purchasing we should endeavour to be reasonably certain that the guarantees will be fulfilled, but with the older and more reputable concerns there is not much to fear in this respect. If the importance of the work appears to warrant it, however, tests of the apparatus may be called for after installation, or before installation, at the works of the manufacturer. In the latter event it may not always be necessary for the purchaser's representative to be present at the test; if the manufacturer is called upon to furnish certified copies of tests conducted at his works for the approval of the customer there are few, if any, that will attempt to practice any deception. The only objection to employing this method

is that in some instances the tests are not conducted in a manner to secure accurate results, and errors, due to carelessness or to inaccurate instruments, are not readily detected on the written report. These errors are fully as apt to work against the manufacturer as in his favour; the writer has seen a number of instances where apparatus has not received the credit it deserves on this account. Certified tests from the works of large manufacturing companies may be somewhat more reliable than those received from smaller concerns, for the reason that the former is apt to have a somewhat better equipment of the rather expensive apparatus necessary for the work, and because the work is so systematized that there is less liability of error on the part of the men conducting the test. On the other hand, some small concerns have an equipment that is entirely adequate, and conduct their tests more carefully than many of their larger competitors. In some instances no extra charge is made for special tests at the factory, either certified or witnessed by the customer's representative; there appears, however, to be a growing tendency to make a comparatively slight charge for the extra work involved. It would appear that such action on the part of the manufacturer is entirely justified and should not be objected to by the purchaser, who is pretty sure to receive the worth of his money. The definite information which he receives will, in most cases, be well worth the cost of the test, and, in addition, he will, in some cases, secure better apparatus than by trusting entirely to the manufacturer's ordinary commercial tests.

MECHANICAL APPLIANCES ON THE PANAMA CANAL

By J. F. Springer

II.—NOTABLE FEATURES OF THE PANAMA CANAL

In the present instalment of his discussion of the mechanical devices which have made the rapid and successful construction of the Panama Canal possible, Mr. Springer treats principally of the locks and the excavation work which their construction involved. The following article will describe more in detail the powerful machinery used in this and other portions of the work and the extent to which the apparatus itself has been created to meet the requirements.—The Editor.

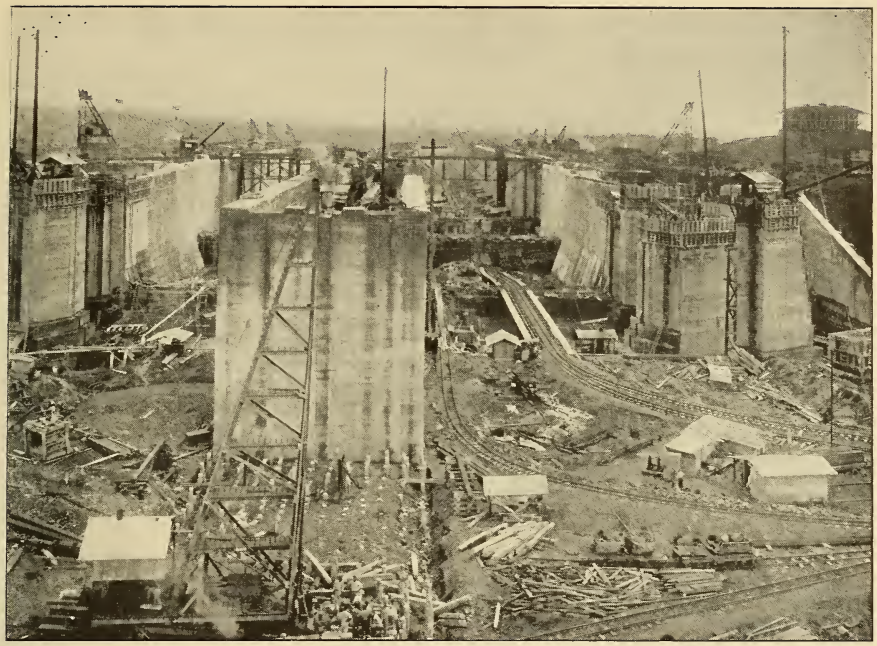
THE termini of the canal route are in fairly deep water, both on the Atlantic and the Pacific sides. On the Atlantic, or northern end, the canal is a channel in Limon Bay. This indentation of the coast is about 4½ miles long by, say, 3 or 3½ wide. The line of the canal lies off the eastern coast. It proceeds in a straight line, which extends in a north and south direction. The portion lying thus in the bay is about 4½ miles in length. It then passes inland, with but little deviation in direction, to the lowermost of the Gatun locks. All this section will be strictly at the level of the sea. It is just about 7 miles from the extreme lower end of the route to the northernmost ends of the lower pair of locks.

Limon Bay is itself rather rectangular in outline. On a peninsula, which forms the most northerly portion of the eastern side, is situated the city of Colon, which has a population of about 19,000. On the western side of the entrance of the bay is Toro Point. Extending out from this point in a northeasterly direction a breakwater is to be constructed. More than one plan has been proposed as to the protective structure on this side of the bay; but the plan which has finally been adopted, after examination of the bottom, is to run out the breakwater in the direction stated to where the depth of the Atlantic is 44 feet. This structure will probably be about two miles in length. To the north, and somewhat to the west of Colon, a second breakwater is to be constructed. It will probably run a little north of west and south of east. A channel 1,000 feet in width is to be provided between these two breakwaters. A ship will find the mouth of the canal just after entering the bay by this passage.

All that part of the canal between the Atlantic termini and Gatun locks is an entire departure from the French plan and construction.

Up to the end of the fiscal year, on June 30, 1911, a total of 359,890 cubic yards of construction had been done on the Colon breakwater. The cost per cubic yard is estimated at $1.8488.

On the Pacific side we have conditions that are somewhat similar. A ship entering the canal will sail in a northwesterly direction, passing a group of islands and a breakwater on the right. To the left as she enters will be Panamarca Rock. This portion of the canal lies in Panama Bay, but does not enter the harbour of the city of Panama. The canal lies entirely to the west of the city. Before quitting the bay the ship, following the canal, will deviate slightly to the east. It will soon after begin the passage of the isthmus itself. For a couple of miles further, until the lower pair of the Miraflores locks is reached, the ship will find a sea-level waterway. On the Atlantic side the fluctuations of the tides occasion a variation in depth amounting to only a foot or two. But on the Pacific side the vertical range of the tides amounts to about 20 feet



CONSTRUCTION WORK ON GATUN UPPER LOCKS, LOOKING NORTH

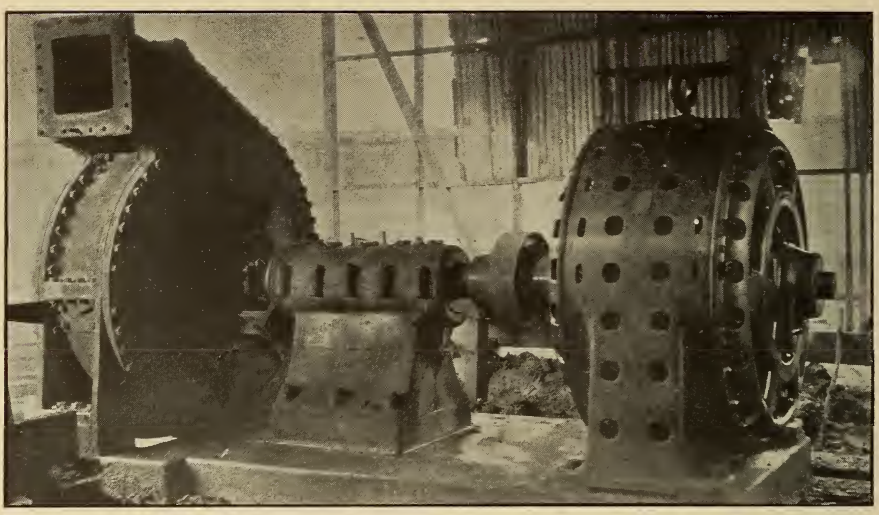
or more. This sea-level section is about 5 miles in length.

Between the termini in the two oceans the canal is about 50 miles in length. The sea-level sections will be 500 feet in width. In fact, this width is the minimum, except for the section known as Culebra Cut, where 300 feet is the rule. A ship coming in between the breakwaters at the entrance to Limon Bay will have a sea-level section 500 feet in width to Gatun locks—a distance of seven miles. Passing through and up the locks, it will come out upon Gatun Lake, where the channel will have a minimum width of 1,000 feet for 15 miles. For the next three miles the channel will be 800 feet wide. This will be followed by a short section of 700 feet width. Then there will be about four miles of channel having a width of 500 feet. Culebra Cut will then be entered, where the minimum width is cut down to 300 feet. The ship will then pass through a lock of the Pedro Miguel locks and come out upon a small body of water—Miraflores Lake. For the one and one-half or two miles through this lake the channel will be 500 feet wide. The Miraflores locks will now be passed, when the ship will enter upon the final stretch at the level of the Pacific. This section, of perhaps a little more than eight miles in length, will have a channel of 500 feet, as already noted.

Aside from the excavation of the prism of the canal, the principal constructional features are summed up in the following list: The Atlantic breakwaters, Gatun locks, Gatun dam, Gatun spillway, Pedro Miguel locks, Miraflores dam, Miraflores spillway, Miraflores locks, the Pacific breakwater. All these are important, though the degree of importance is by no means the same with all. The construction of the canal has involved the re-location of the Panama Railroad. This has been quite an undertaking in itself.

PEDRO MIGUEL

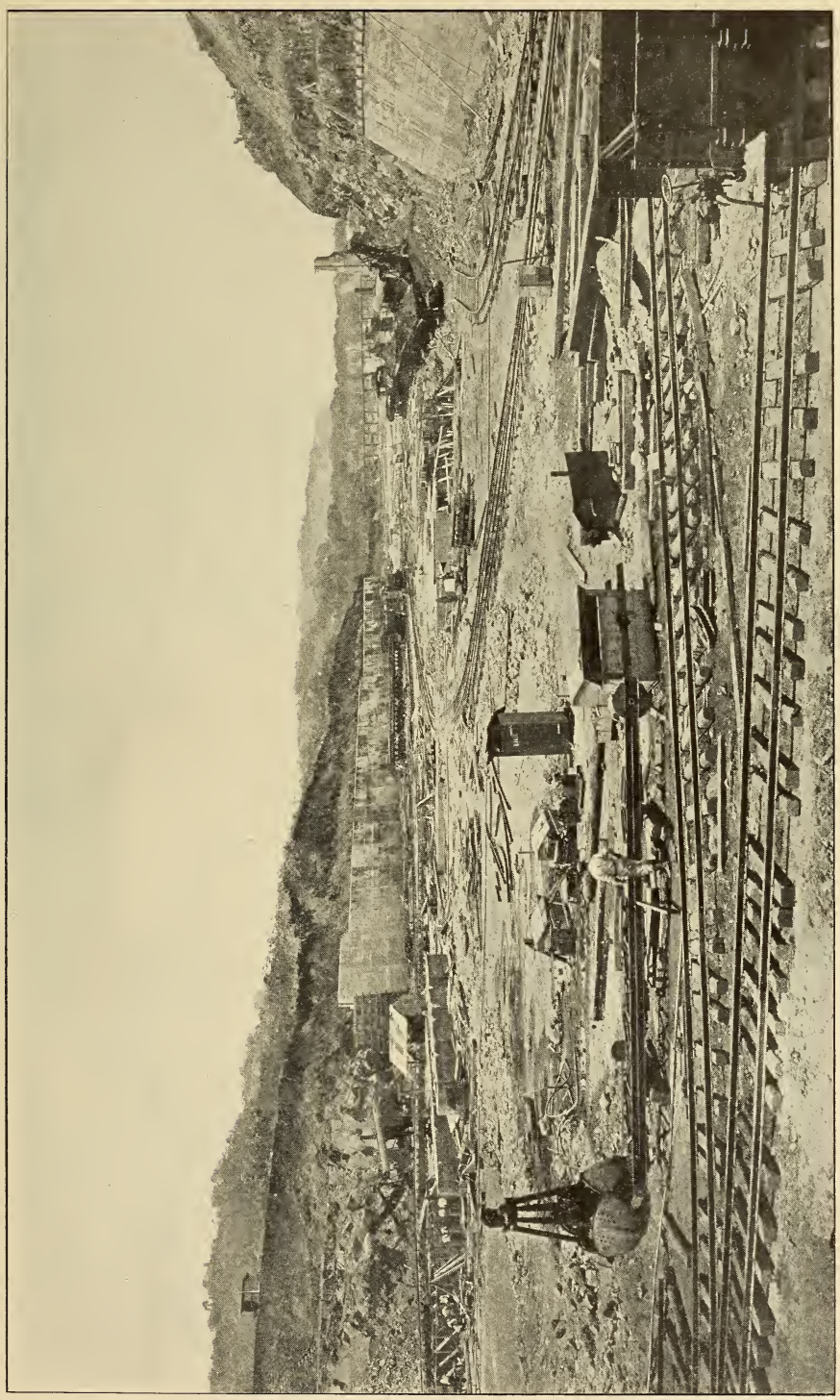
The Pedro Miguel locks mark the southern limit of the high-level sec-



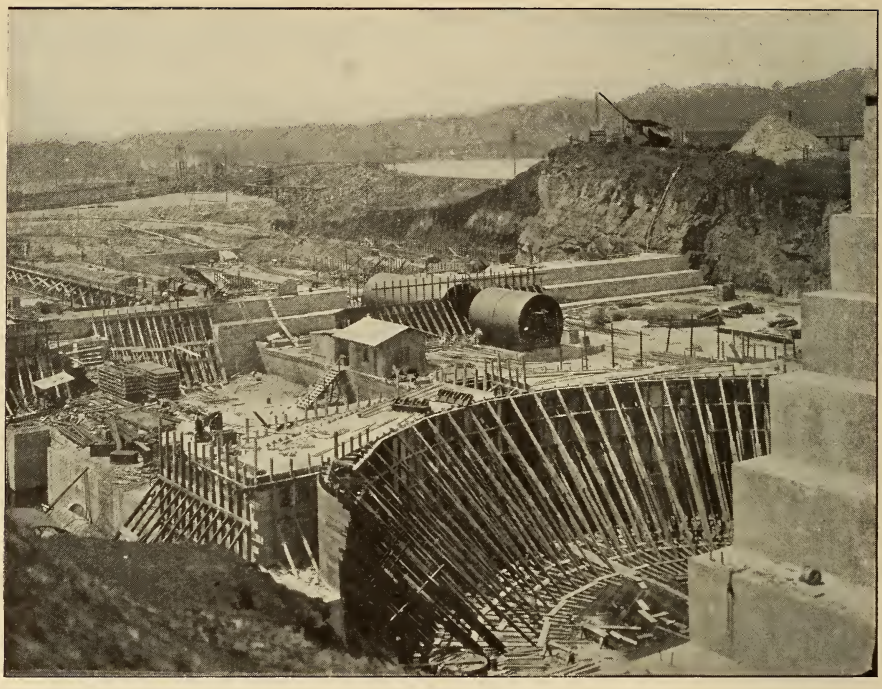
WESTINGHOUSE INDUCTION MOTOR OF 655 H. P. DRIVING DREDGE PUMP FOR GATUN DAM

tion. Here a pair of single-lift locks are under construction. The drop in level to the Miraflores Lake will be about 30 feet. The direction of the Canal axis at this point is about northwest and southeast. The configuration of the general surface and of the underlying rock at the location of the locks is such that an eastern and a western dam are required. The one to the east will be, however, a very simple affair. It is to consist of a core wall of concrete carried down to the rock. Its purpose is to prevent seepage. It will be, for the most part, beneath the general surface. It is to run northwards from the northeast corner of the locks. On the west side the situation is not quite so simple. Here the surface falls off in the direction of what will be Miraflores Lake. There is to be constructed at this point a considerable dam, which will sustain the pressure of the water against the western side of the terminal portion of the high-level section. This terminal portion includes the side wall of the western lock and a short section of the western bank of the canal just north of the locks. If one imagines himself on shipboard coming out from Culebra Cut, after the completion of the canal, and sailing for the western lock, this dam will be on his right. If he should leave the vessel at a point a little in advance of the entrance to the locks proper, he will find himself upon a level area. If he walks transversely to the canal axis, he will come to a ridge.

Upon mounting to the top of this and looking down on the other side, he will find a terrace below him. This terrace descends in its farther edge to the waters of Miraflores Lake. The ridge upon which he stands is the principal part of the dam. The toes to front and rear consist of rock fills. The portion beneath his feet and between the two toes is made up of selected material. The toe to the front is really part of the terrace below. The farthest portion towards the lake is waste material. His feet are 105 feet above the sea level. The summit of the rock toe on the canal side is 92 feet; of the one on the lake side, 85 feet. Eighty-five feet is the typical level of Gatun Lake, and so of the canal itself at this point. Between the rock toes and beneath the intermediate filling of selected material is a puddled core. The base of the dam is very wide. There would be but little reason to seek for econ-



THE SPILLWAY AT GATUN TO PROVIDE OVERFLOW RELIEF FOR THE FLOODS OF THE CHAGRES RIVER DURING THE RAINY SEASON



GENERAL VIEW OF CONSTRUCTION WORK IN GATUN LOCK CONCRETING
Water shown on right is hydraulic fill, the elevation on left of water is south toe of dam.

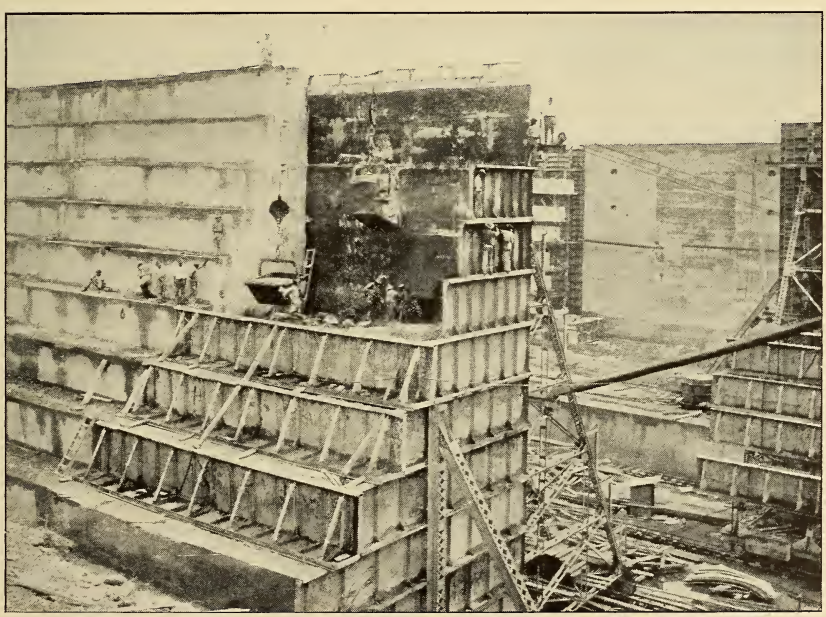
omy by narrowing the base, as both the rock for the toes and the material filling come from the canal prism, and, if not used here, they would be wasted. The southern end of the ridge or dam is curved in a little towards the east, to join the northwest corner of the locks. The terrace continues southward along the western side, and assists, together with the rock fill next Miraflores Lake, in restraining the lock wall. The ridge and terrace may, together, be considered as a single dam.

The central wall of the locks begins quite a little distance to the northward of the main structure. Its summit will rise to elevation + 92 feet, which is 52 feet above the canal bottom. The width of this wall will be 60 feet. The preliminary portion will be solid, but the portion forming the division between the two compartments of the locks will have a longitudinal groove. For a part of the distance the side walls of this groove will be stepped. The side walls will likewise be stepped on the exterior sides. This reduction of the thickness of the wall towards the top corresponds with the decrease in the hydrostatic head which will have to be resisted. The central wall and the two side walls will be perforated longitudinally to provide passageways for the incoming and the outgoing water. The culvert in the centre wall will have its under surface somewhat above the floors of the adjoining locks. At intervals, branch culverts of diminished size will lead off in the transverse direction. These will dip down to a point below the floor level, when they will continue beneath the floors. Communication with the lock chambers is secured by vertical openings. When it is desired to fill a lock, water will be admitted into the central longitudinal culvert, whence it will find entrance into the lock chamber itself. Alternating with the small cross culverts

connecting with the supply culvert are other small cross culverts. These join large culverts arranged longitudinally on the side walls of the locks. Now these large culverts have their bottoms below the floor level of the lock chambers, and have connections with the chambers by means of springs from their cross culverts. They thus provide a means of discharging the water from the chambers. The floors of the Pedro Miguel locks will be quite thin, as they will rest on sound rock. A part of the central wall will consist of a dike or trap rock, which has been found to be suitably situated for the purpose.

MIRAFLORES

There is but little change of direction as the canal continues across Miraflores Lake. The normal level of this body of water is at elevation + 55. This is 30 feet below the surface of Lake Gatun. The drop of these 55 feet to the sea-level section on the Pacific side is accomplished by the double-lift Miraflores locks. The total lift is divided equally between the upper and lower compartments. Here, as at both the other points of lockage, the lock arrangements are in duplicate. At the spot selected for this structure there are two hills, both of which rise to heights considerably above the surface of Miraflores Lake. The transverse line of the canal runs about northeast and southwest, these hills being north and south of one another. In order to provide suitable conditions, the southern hill is continued towards the north by a dam or dike in such way that the latter has its northern end nearly opposite the other hill. The canal lies between. This spur from the southern hill occupies a position between the locks and Miraflores Lake. Together with the hill from which it springs, the spur protects the western lock wall from the lakes. This dam will consist of rock toes and a hydraulic fill. At either end concrete core walls carried to rock will connect the dam, in the one case with the lock wall and in the other with



GATUN MIDDLE LOCKS. CONSTRUCTION OF WEST SIDE WALL, SHOWING USE OF METALLIC FORMS FOR RETAINING CONCRETE

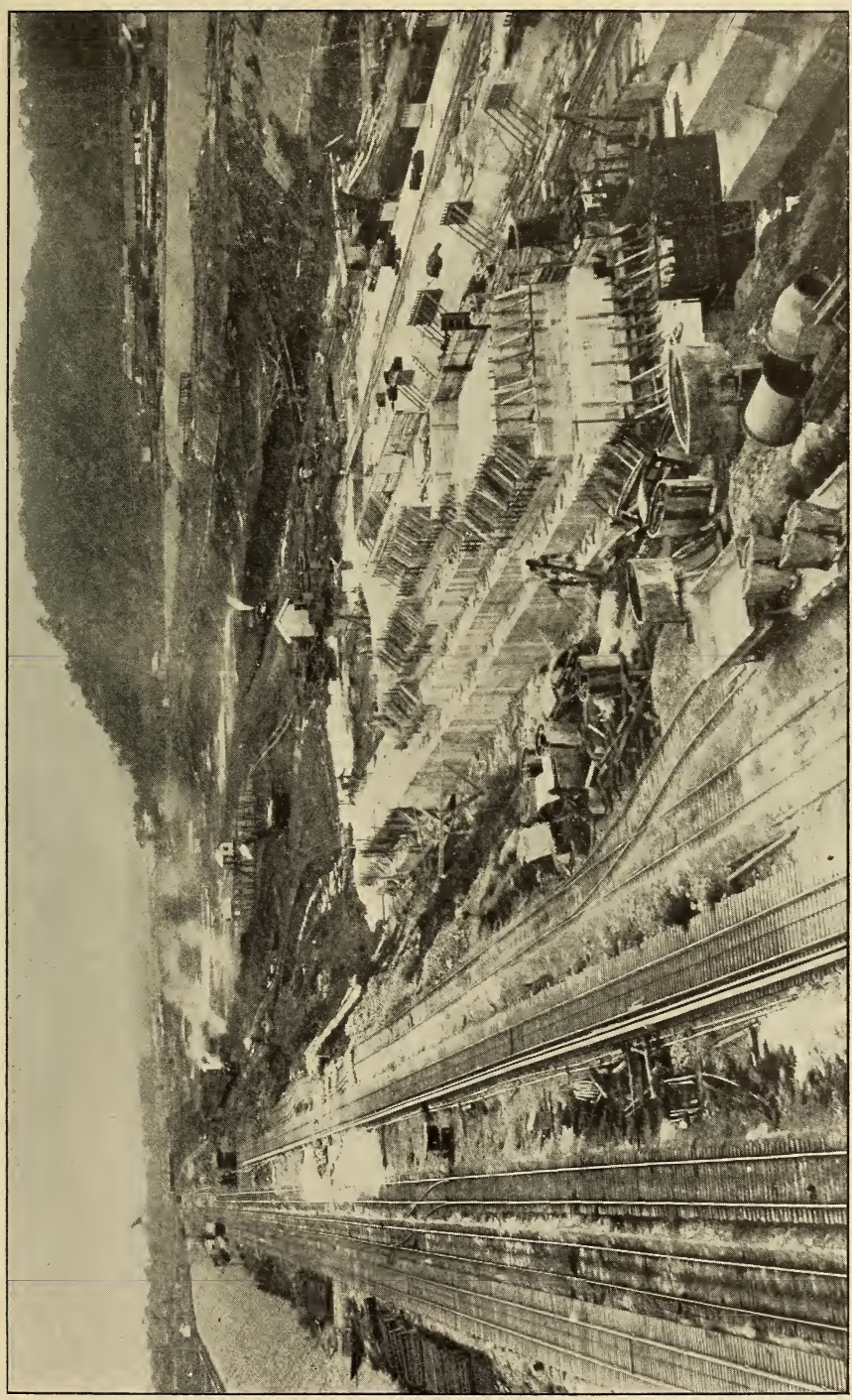
VIEW AT MIRAFLORES, SHOWING HYDRAULIC JET IN ACTION

the hill. The foundation is everywhere impervious except at the intersection with the bed of a stream. At this point a core of puddle 20 feet wide has to be carried down to rock. Along the remainder of the axis a puddle wall, 20 feet wide and 12 feet deep, has been constructed beneath the level of the fill. In this way a bond is secured with the underlying soil.

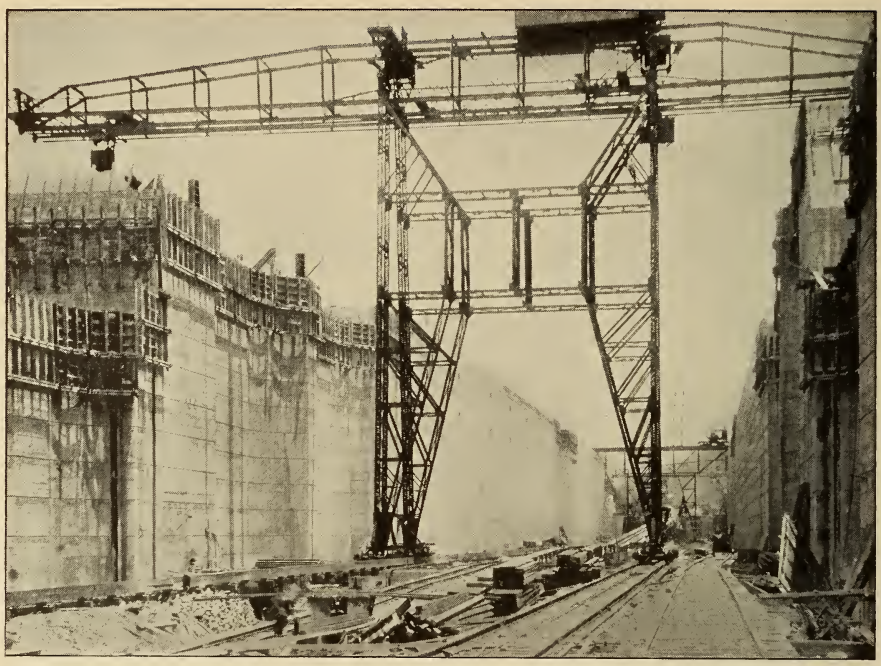
CONSTRUCTION AT PEDRO MIGUEL AND MIRAFLORES

The amount of excavation involved at Pedro Miguel and Miraflores has been very considerable. Thus, the excavation of the dam and locks at Pedro Miguel amounted, on June 30, 1911, to 1,039,154 cubic yards. At Miraflores, the excavation connected with the various constructions amounted, upon the same date, to 2,260,606 cubic yards. Of this, 28 per cent. was not excavation. At Pedro Miguel, the figures above given probably represent about all the excavation proper required. With the exception of a small amount done on the site of the dam, the cost, including administration and general expenses, per cubic yard was $0.9649. On the site of the dam, the cost was considerably more, $1.5138 per cubic yard. The preparation of the foundations for the locks involved an expense of $2.8424 per cubic yard. At Miraflores the great bulk of the dry excavation, which was on the site of the locks, was done at a cost of $1.0156 per cubic yard. On the sites of the dams and spillway, the expense was $1.3753. The wet excavation, by the dredge and hydraulic methods, was performed at an average cost of about 53.5 cents. The preparation of the foundations for the locks cost $1.9305 per cubic yard. In giving the figures of the excavation yardage at Pedro Miguel and Miraflores the work involved in the preparation of foundations was not included. The excavation at Miraflores was not complete at the end of the fiscal year in 1911.

At Pedro Miguel, a total of 665,056 cubic yards of masonry had been put



GENERAL VIEW OF MIRAFLORES LOWER LOCKS, LOOKING SOUTH



PEDRO MIGUEL LOCKS, WEST CHAMBER, LOOKING NORTH, SHOWING WELLMAN-SEAVER-MORGAN CHAMBER CRANE

in place before July 1, 1911. The average cost per cubic yard was $5.3992. At Miraflores, before the same date, an amount equal to 274,563 cubic yards was in place, having cost on the average of $5.0162 per cubic yard. The masonry cost includes the expense for concrete, forms, reinforcement, etc.

THE SPILLWAY AT MIRAFLORES LAKE

The great area of Gatun Lake is relied on to provide for the control of sudden inrushes of water from the surrounding watersheds. It must be remembered, however, that the level of this lake is above those of other portions of the canal. Thus, Miraflores Lake, situated as it is between the locks of Pedro Miguel and Miraflores, is 30 feet below the level of Gatun Lake. Moreover, the size of this body of water is comparatively small. If, then, some accident at the Pedro Miguel locks should permit the inrush of water from Gatun Lake by way of Culebra Cut, more or less serious damage might result to the earthern dams, if some adequate means of control were not provided. It seems that it is not easy to estimate the possible inflow with precision. If 95,000 cubic feet per second be taken as the proper estimate, then the size of Miraflores Lake is such that a rise of its level would occur at about the rate of 0.1 foot per minute. It will be seen at once that we have here a very real danger. With the possibility of a rise of level at the rate of 6 feet per hour, the means of control must be thoroughly adequate. It is proposed to deal with such a contingency as that described by two means, the principal of which is a spillway 432 feet in length. The canal at the Miraflores locks runs northwest and southeast. The spillway will extend northeast from the northeastern side of the upper locks to the side of a hill, and it is estimated that this piece of construction will require about 75,000 cubic yards of concrete. In cross-section, the spillway discloses the ogee form

of downstream face, the curve of the upper portion being a parabola, merging into a rather sharp circular curve below. The sharpness of the lower curve is considered quite permissible from the facts that the total fall of the water is inconsiderable and that the discharge is into a deep pool.

The form of the upper curve is such that when the water flowing over the crest is six feet or more in depth adherence of the under surface of the stream to the face of the dam will take place. An approach wall is to be constructed to either side to connect the spillway with the lock wall and the hill. The crest will be located about 16 feet below the ordinary level of Miraflores Lake. It will be 38.67 feet above the mean sea level. Eight bays will be arranged on the crest. These will be closed by rising gates of the design known as the Stoney type. It is proposed to provide a longitudinal tunnel through the dam near the crest; and to install in it the machinery necessary for the operation of the gates. As the number of bays is eight, there will be seven piers separating them from each other. When a gate is opened, the water will at once begin to flow over the crest, but it may not adhere to the surface until the opening is 6 feet in height. However, it is thought that thin streams of a few inches will have no bad effects. Consequently, it will be permissible to operate the spillway by opening a number of gates a short distance, or it will be allowable to open a single gate to the full width. It is thought that perhaps the latter method is to be preferred because of the practice it gives the operators and of the opportunity afforded to make examination of the upstream faces of the gates.

Because of the possibility of a rapid rise in the level of Miraflores Lake through some breakdown at Pedro Miguel, there must be no uncertainty or delay in the operating of the gates when the spillway is to be put into such emergency service. It is probable that "automatic self-starters actuated by float switches" will be employed.

In an emergency in which the spillway might be found inadequate, it is proposed to utilize the culverts of Miraflores locks. Their capacity is to be such as to take care of 25,000 cubic feet per second. It is thought that this is three times the probable service required as auxiliary to the spillway.

Moreover, both spillway and culverts would begin to feel relief as soon as the emergency dam at Pedro Miguel was closed. This would be accomplished in a short time.

We are indebted to the Atlas Portland Cement Company for the photographs from which the illustrations on pages 255, 257, 258, 259 and 261 have been made.

(To be continued.)

HIGH-SPEED TURBINE PUMPS

By J. W. Rogers

THE growing popularity of high and low-lift centrifugal or turbine pumps for mining purposes has done much towards the considerable progress in the design and construction of these machines which has taken place during the past few years, and when the undoubted advantages of this type of pump are considered, it is not a difficult matter to understand why it has very largely superseded the various forms of the reciprocating type of pump, more particularly for shaft-sinking operations.

A few of the advantages which it is generally admitted the centrifugal has over the reciprocating type of pump for collier and mining work may be concisely summed up as follows:

(1) Its freedom from breakdown, due to its substantial and simple construction and absence of wearing parts in contact, except bearings.

(2) Its adaptability to either direct, belt, or gear driving, and noiseless operation.

(3) Its low cost of upkeep, due to absence of leaky valves.

(4) Its ability to deliver a uniform flow of dirty and gritty water, thus avoiding vibration and straining of pipe joints.

(5) Its economy in cost of foundations, due to small and compact dimensions.

(6) Its capacity for dealing with large volumes of water and high lifts.

Its introduction into mining work some years ago, chiefly for the unwatering of old mines and the drainage of new sinkings, offered plenty of scope for the exercise of these good qualities.

Another cause of the rapid development of the centrifugal pump is the growing tendency towards the use of high-speed steam turbines and electric motors; in fact, it is mainly due to the possibility of obtaining high-speed rotary movers that the centrifugal pump has reached its present state of perfection and become so extensively used in the wide field of service wherein the reciprocating pump formerly occupied the premier position.

Although much descriptive matter relating to different makes and classes of centrifugal pumps has appeared at different times in the technical press, information dealing with the practical points involved in the operation of these machines has not been so plentiful, and for this reason the writer thinks the following notes should at least prove of interest.

As an introduction, it might be well to briefly consider the general principles on which the operation of a centrifugal pump is based, and also the practical points which have an important bearing on the operation of both types of pump under different conditions of working.

As is well known, the elements of a modern high-lift centrifugal pump consist of a series of rotating discs, or impellers, mounted on one shaft, which, when rotating at a high speed, suck up the water and deliver it through a series of guide vanes or diffusers formed in one enclosing casing and corresponding to the stationary guide buckets of a turbine.

Each impeller delivers the water into the system of guide vanes, the curved passages of which gradually widen, and the effect of these diffusion passages is to convert the velocity of the water leaving the impellers into hydraulic pressure, which is gradually increased step by step as the water passes through the series of vanes.

The high efficiency of the modern turbine pump depends, to a great extent, upon the careful design of this system of guide vanes and on the correct conversion of the energy of velocity into pressure, the velocity of the water after leaving these vanes being about 6 feet per second.

The water enters the pump casing axially and passes through the revolving impellers at high velocity, being then discharged tangentially through the guide vanes into the volute, by which time most of the kinetic energy of discharge velocity has been converted into the requisite amount of pressure energy necessary to overcome the static head and friction.

The total pressure head produced by a centrifugal pump depends upon the tangential velocity at the circumference of the impellers, and is limited by the highest circumferential speed at which a pump will operate, the height of lift being a constant for any particular value of tangential velocity, whether a pump is of large or small dimensions.

The head to be reached by one stage depends upon the quantity of water to be pumped and the width of the impeller, and in the case of a well designed pump it is possible to produce a lift of 330 feet with a single stage.

In modern practice, however, the limit of 230 feet per stage is rarely exceeded, and for this reason when high lifts are required it is necessary to put pumps in series, or, what amounts to the same thing, to employ several impellers and a corresponding number of guide vanes in one casing, the combination forming a multi-stage pump.

As already stated, the height of lift produced by a pump depends upon the speed of the impellers, and any change in speed will result in a corresponding variation in pressure, also in the quantity of water discharged which is directly proportional to the speed; but the head varies directly as the square of the speed.

With further reference to the system of guide vanes, which were first introduced by Messrs. Sulzer Bros., although these require a pump casing of more expensive design and construction than that used with the old type of centrifugal pump, the advantages attending their use are of great importance, and this question may be considered as follows:

The introduction of guide vanes constitutes one of the most important improvements which have taken place in the design of high-lift pumps during recent years.

As is well known, in the old type

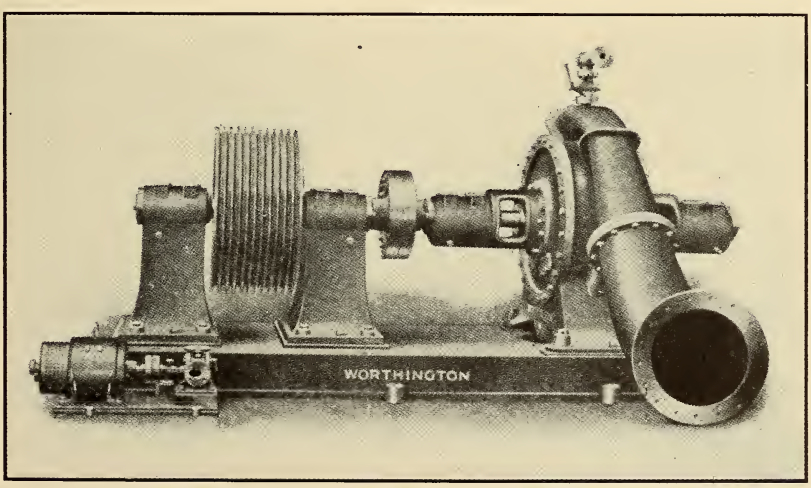


FIG. 1.—WORTHINGTON 20-INCH MEDIUM-LIFT CENTRIFUGAL PUMP, ARRANGED WITH ROPE PULLEY

of centrifugal pump the water was discharged direct from the impeller into the volute, which was the cause of considerable loss, due chiefly to the sudden change in the velocity of the water in the volute. Now the effect of these guide vanes is to cause the whirling velocity to gradually decrease and the static pressure to gradually increase, with the result that the water is delivered into the volute at a comparatively low velocity and high pressure.

Another source of loss was the shock, caused by the water entering the impeller and having suddenly impressed upon it the full whirling velocity; but this is minimised to a great extent by the guide vanes, which cause the flow of water through the pump to follow a continuous spiral path from suction to discharge.

It should be stated that the use of guide vanes between the diffusion chamber or volute and the impeller is not absolutely necessary in low and medium-lift pumps, and there are several makes of pumps at present on the market which are designed to give a high efficiency when working against heads up to 150 feet without the assistance of guide vanes. The illustration in Fig. 1 represents a 20-inch Worthington medium-lift pump having a casing of special design, which enables the velocity of the water to be converted into the required static pressure without passing through diffusion passages. The design of this casing is such that all indirect or tortuous channels for the water are avoided; and by this means all the losses, due to the alternate large reduction in velocity and corresponding increase in static pressure which takes place continuously in the ordinary type of centrifugal pump, are, to a great extent, eliminated.

Another important point in the design of centrifugal pumps is the curvature given to the blades of the impeller, which may be either (a) backward curved, (b) forward curved, or (c) radial, the angle between the blade and a radial line passing through the centre of the impeller being generally about 75 degrees for ordinary low-lift pumps having backward-curved blades.

Although an efficient pump may be designed with radial or forward-curved blades, it is generally found that the efficiency is considerably less than with backward-curved blades, and for this reason impellers of this latter shape are used in modern pumps.

CHARACTERISTICS

The general characteristics of centrifugal pumps which have an important bearing on their operation under different working conditions may be considered as follows:

It is important to appreciate the vital difference between the operating characteristics of a centrifugal and those of the reciprocating type of pump. As already stated, with a centrifugal pump the pressure head varies as the square of the speed, the quantity of water discharged being directly proportional to the speed. In the case of a reciprocating pump, on the other hand, although the quantity discharged is also directly proportional to the speed, the head will remain practically constant at all speeds. It will, therefore, be seen that the pressure characteristic of a centrifugal pump gives it a great advantage over the reciprocating type, as it is impossible to subject the pump and discharge pipe line to a higher pressure than that corresponding to the operating speed. For this reason it is quite possible to run a centrifugal pump at its normal speed with the discharge valve closed. It is a well-known fact that when a centrifugal pump is running at constant speed and the head is gradually increased a point is reached at which the pump ceases to deliver any water, because the head at this point will balance the pressure on the pump and the impeller will simply be churning the water in the volute.

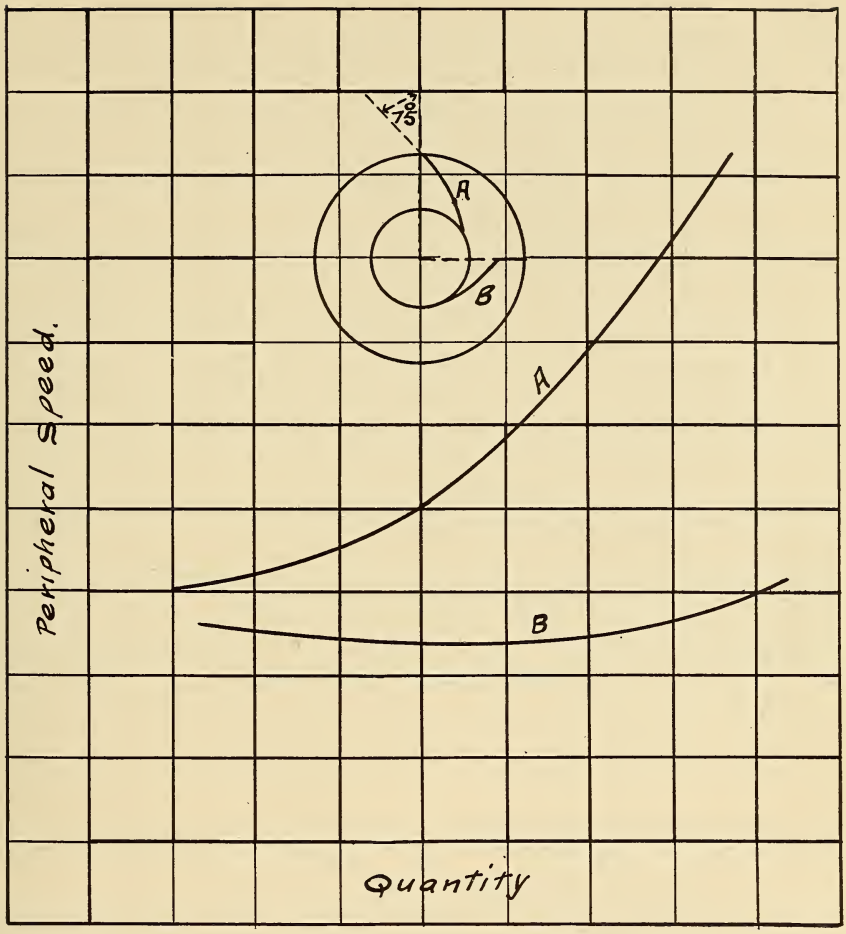


FIG. 2.—CURVES REPRESENTING THE CHARACTERISTICS OF TWO PUMPS, BOTH CAPABLE OF DELIVERING AN EQUAL AMOUNT OF WATER AGAINST THE SAME HEAD

Under these conditions, which are similar to those existing when the pump is running at its normal speed with the discharge valve closed, the load on the pump is a minimum, and it would absorb about 40 per cent of its power at full load.

It may be mentioned that a high-speed turbine pump should not be run up to speed before being flooded with water, and it is quite unnecessary to add that if a reciprocating pump was operated under the above conditions the results would be disastrous.

It will, therefore, be seen that, while closing the discharge of a reciprocating pump will result in it being heavily overloaded, this operation has quite an opposite effect with a centrifugal pump, on which the load is increased by opening the discharge valve, which is due to the fact that when the pressure in the delivery is reduced, owing to an increase in the opening of this valve, or through a reduction in the manometric head, the surplus pressure produced by the pump is converted into velocity, thus causing an increase in the quantity of water discharged.

A centrifugal pump may also be overloaded by increasing its speed above the value required to gener-

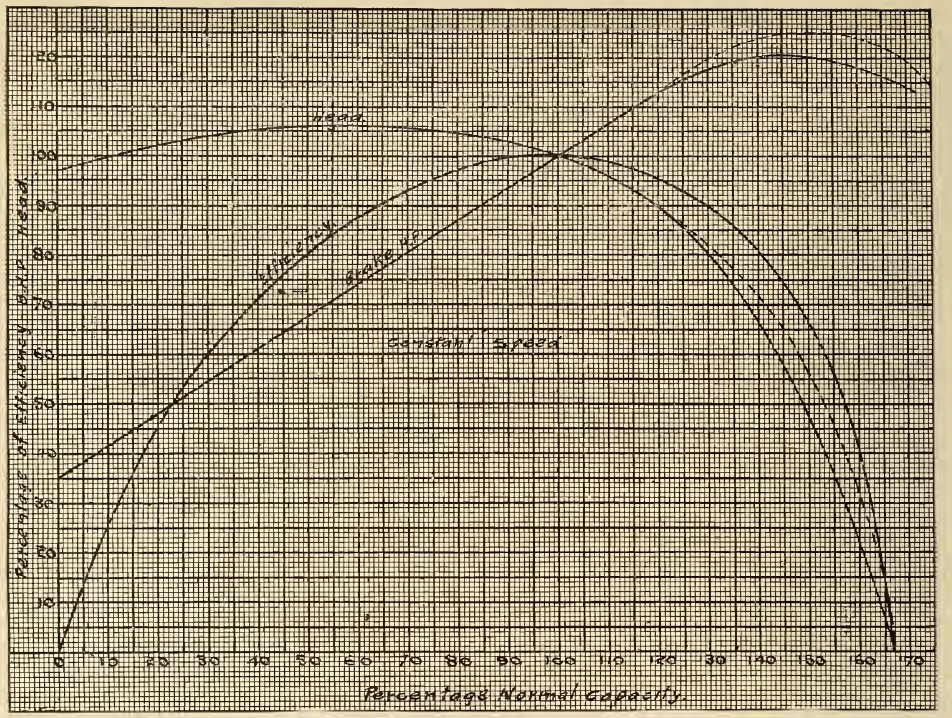


FIG. 3.—SPEED CURVES REPRESENTING THE VARIATION IN HEAD, EFFICIENCY, AND BRAKE HORSE-POWER, WITH AMOUNT OF WATER DISCHARGED, OF THE WORTHINGTON PUMP

ate the normal discharge pressure.

It may be well to mention that the total manometric head H to be overcome by a centrifugal pump includes (a) suction head H_1, (b) pressure head H_2, (3) friction head H_3, due to the velocity of the water in the discharge pipes.

$\therefore H = H_1 + H_2 + H_3$, and a variation in any of these quantities will alter the load on the pump.

When a centrifugal pump is running at a constant speed and the manometric head is altered by varying the amount of opening in the delivery valve, the pump will deliver varying quantities of water at "heads" which increase at first and then decrease as the valve is opened to its fullest extent.

A centrifugal pump has a greater tendency to be overloaded as the manometric head is decreased when its impeller has radial or forward-curved blades, as these are capable of discharging a larger volume of water at the same speed when the head is decreased.

On the other hand, the chief advantage of backward-curved blades is that it is possible to vary the volume of water discharged by varying the speed of the pump; but with radial blades this is not possible.

This point is well illustrated by the curves in Fig. 2, representing the characteristics of two pumps, both of which are capable of delivering an equal quantity of water against the same head. The curve marked A gives an idea of the relation between the quantity of water delivered and the speed with an impeller having blades curved backwards at an angle of 75 degrees, curve B representing the performance of a pump with an impeller having radial blades; the lowest point on each curve indicates the minimum quantity the pump will deliver. A reference to

these curves shows that a backward-curved impeller will give a wide variation in the quantity delivered when the speed is varied., but with forward or radial blades the variation between quantity and speed is considerably smaller. Further, with forward or radial blades the load on a pump running at constant speed increases very rapidly when the quantity of water delivered exceeds a certain limit, and when the manometric head against which such a pump is working is reduced the motor would be seriously overloaded, and for this reason its full-load rating should be about 33 1/3 per cent. above the value actually required by the pump to give its normal output.

In the case of an impeller having backward-curved blades the overload resulting from a decrease in the manometric head is small, and this overload characteristic is shown by the curves in Fig. 3, representing the variation in head, efficiency, and brake-horse-power, with the quantity of water discharged, of Worthington turbine pumps, the full-line curves being for medium-lift and the dotted curves for high-lift pumps. These curves show that the brake-horse-power increases as the head is decreased, and, at the same time, the efficiency falls off. The increase in the power required with a decrease in the head is, to a great extent, due to the drop in efficiency caused by the greatly increased friction set up by the larger volume of water which flows through the pump when the head is decreased. The extent of the overload produced in this manner is, in some designs of pump, very considerable; but Worthington pumps are so designed that the maximum overload which can possibly occur through a reduction in the total head is limited to 25 per cent.

It follows, therefore, that a motor having reasonable overload capacity is not likely to be seriously affected by the momentary overloading of centrifugal pumps of this type.

These curves have been plotted on a basis of constant speed, and they show that while the capacity is vary-

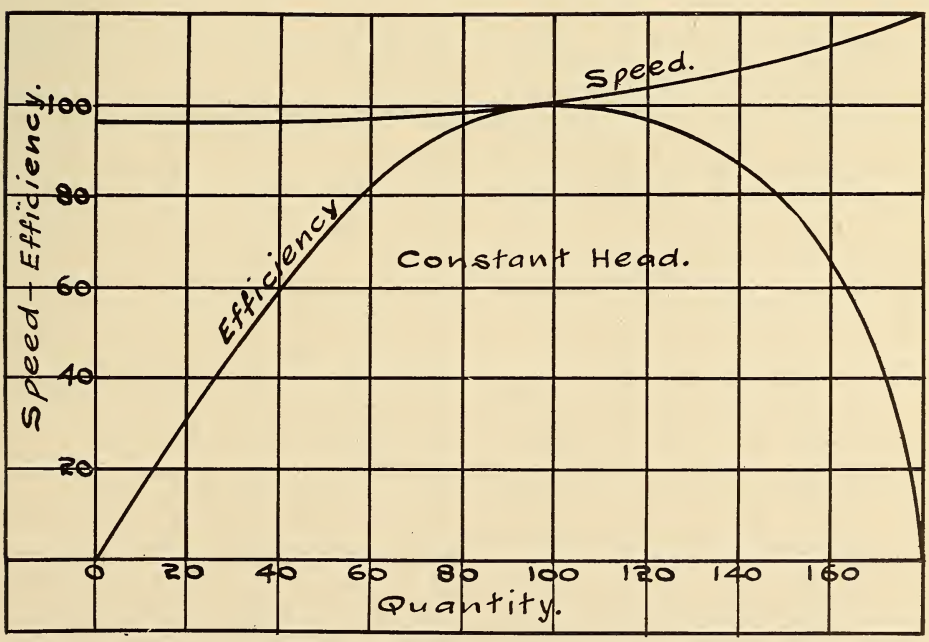


FIG. 4A.—PERFORMANCE OF A MATHER & PLATT STANDARD TURBINE PUMP, GIVING THE OPERATING CONDITION OF CONSTANT HEAD, IN CURVES

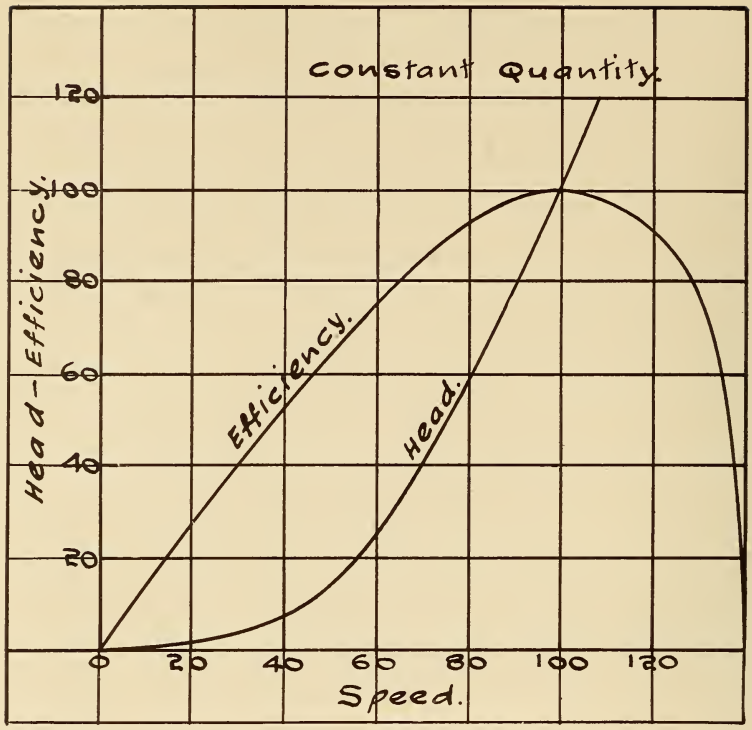


FIG. 4B.—CURVES GIVING THE OPERATING CONDITION OF CONSTANT QUANTITY OF THE MATHER & PLATT PUMP

ing from 70 per cent. to 120 per cent. and the variation in head about 20 per cent., the pump efficiency only drops about 5 per cent. below its normal value. When a pump is designed for a given quantity and lift, its performance is not always satisfactory under other conditions; but a pump will run under various conditions if the quantity discharged is increased in proportion to $\sqrt{H}$, where H represents the height of lift.

A very interesting series of curves is shown in Fig. 4, representing the performance of one of Mather & Platt's standard turbine pumps under the different operating conditions of (a) constant head, (b) constant quantity, (c) constant speed, the various quantities being shown as a percentage of their normal value. It is of interest to note that Mather & Platt were the original makers of the turbine pump, which was first introduced in the year 1876, and although such plant has been greatly improved during recent years, a modern pump still possesses features of the original design. Although best adapted for direct coupling to electric motors, a centrifugal pump can also be driven by water or steam turbines and high-speed engines, and the installation in Fig. 5 represents a Mather & Platt turbine pump driven by a 1,800 brake-horse-power Yoelly steam turbine, and capable of dealing with 10,500 gallons per minute against a head of 410 feet. The efficiency of a turbine pump depends, to a great extent, on the power required to rotate the impeller in the liquid pumped, and varies between 50 per cent. and 85 per cent., according to the design. The work done by a centrifugal pump in effective horse-power, as expressed by the

weight of water raised, is given by $Pe = \frac{Q \times H}{60.75}$, when Q is in kilograms and H in metres; also. $Pe = \frac{Q \times 10 \times H}{33{,}000}$, where Q is in gallons and H in feet.

∴ The power required to pump water against a given total manometric head is given by $H\ P = \frac{Q \times 10 \times H}{n \times 33{,}000}$, where H = manometric head in feet, Q = quantity in gallons per minute and n = mechanical efficiency of pump.

If the power input to motor is *Pi*, the overall efficiency of the combination = *Pe* over *Pi*, but the efficiency of the pump alone will be greater than this, as there is a loss in the motor; and if the combined efficiency = .63 and motor efficiency = .9, then pump efficiency $= \frac{.63}{.9} = .7$.

A knowledge of the power required to drive a centrifugal pump against its rated head at normal speed is not sufficient to determine the capacity of the motor required, owing to the fact, as already stated, that a variation in the total head will result in an overload which may be far in excess of the rating as calculated from the data given above.

The power consumed varies, to a great extent, with a change in the speed; and as the efficiency falls off very rapidly when the total head is decreased below its normal value, the power required to drive a pump may be greatly increased. It will, therefore, be seen that it is of the greatest importance to install motors having a very liberal rating for the satisfactory driving of centrifugal pumps, and the following example shows the effect of a change in the head on the power required.

Suppose a pump to be working against a 100-foot head and the tangential velocity at the circumference of the impeller is 100 feet

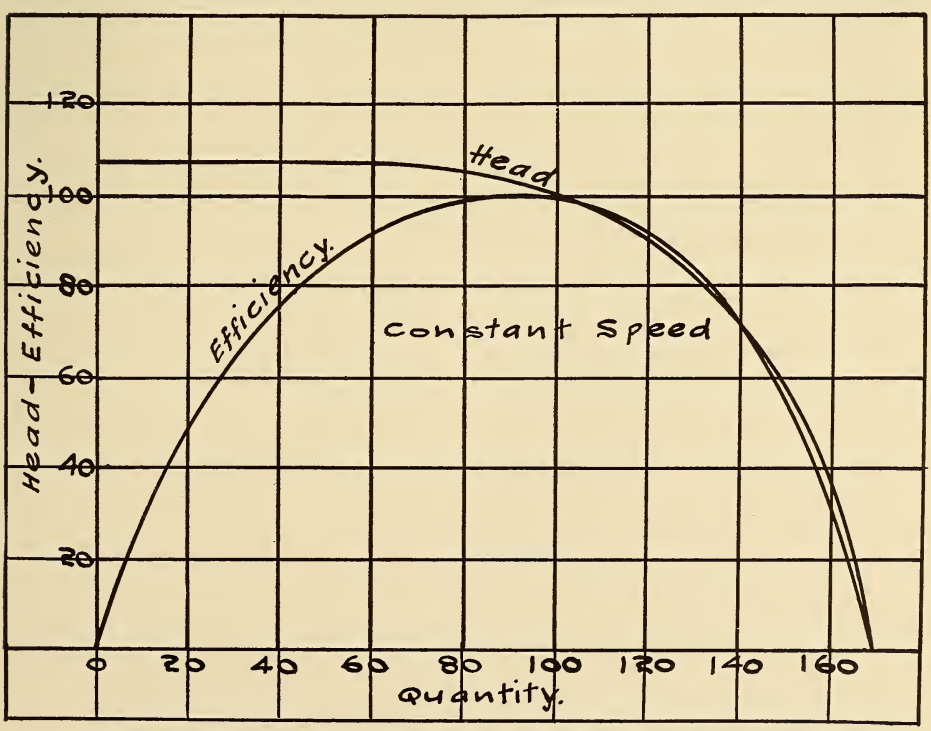


FIG. 4C.—CURVES GIVING THE OPERATING CONDITIONS OF CONSTANT SPEED OF THE MATHER & PLATT PUMP

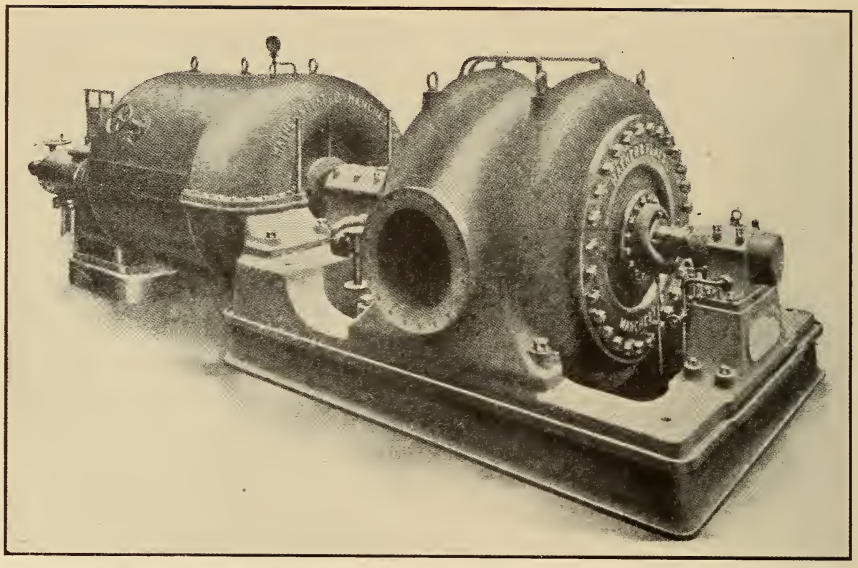


FIG. 5.—SPECIAL HIGH-SPEED TURBINE PUMP DIRECT COUPLED TO MATHER & PLATT-ZOELLY STEAM TURBINE OF 1,800 BRAKE HORSE-POWER

per second. Now to lift water to any given height, theoretically it must be given a centrifugal force = $\sqrt{2gH}$, where H is the height of lift and g the accelerating force = 32.2 pounds.

As the velocity of the water leaving the impeller is 100 feet per second, then velocity of discharge:

$$V_1 = 100 - \sqrt{2gH}$$
$$= 100 - \sqrt{2 \times 32.2 \times 100}$$
$$= 19.8 \text{ feet per second.}$$

If the head is reduced to 50 feet, then velocity of discharge $V_2 = 100 - \sqrt{2 \times 32.2 \times 50} = 43.3$ feet per second.

The quantity delivered is directly proportional to the discharge velocity and inversely proportional to the head.

$$\therefore \frac{Q_2}{Q_1} = \frac{43.3}{19.8} = 2.2$$—that is to say, when the head is decreased to 50 feet the pump will deliver more than double the normal quantity of water. This example clearly shows that the extra pressure produced by the pump when the manometric head is reduced to 50 feet results in an increase in the discharge velocity, and, consequently, an increase in the quantity discharged.

The power rating of motors intended for driving turbine pumps is generally as follows:

For motors up to 5 brake-horse-power output, overload capacity = 50 per cent.

For motors up to 30 brake-horse-power output, overload capacity = 25 per cent.

For motors over 30 brake-horse-power output, overload capacity = 10 per cent.

(To be concluded.)

TO SEA BY RAIL

By M. B. Claussen

R. J. PARROTT, PRESIDENT, FLORIDA EAST COAST RAILWAY

AS a boy, the writer remembers a lady, the wife of a wealthy man whose business took him to Europe yearly, who had such a horror of the sea that she always said to persons who asked why she never crossed with her husband, she was waiting until a bridge was built across the ocean. If the destination of that lady had been Cuba, a sea trip which she, no doubt, would have dreaded as much as an ocean crossing, it would be about time for her to pack her trunk, now that the Key West extension of the Florida East Coast Railway is completed, as she could board a train in New York and step out of her car in Havana, Cuba, forty-eight hours later, traveling all the way, except the last 90 miles, by rail, the last 90 miles being made by ferry, which took the train itself through to Cuba.

This extension is built by using the Florida Keys as stepping stones and constructing on them and across the stretches of open water between them mile after mile of steel and concrete viaduct, until Key West and the last bit of land formed by the low reefs which curve round the lower end of Florida far out into the blue waters of the Gulf is reached.

This road has 46 miles of construction over the water, the foundations of which are from a few feet to 36 feet below mean low tide level. This unique railway, 156 miles in length, was started in 1905 and formally opened on January 22, 1912.

This notable engineering achievement had its birth in the mind of Mr. Henry M. Flagler, who has had the idea constantly in mind ever since the Spanish-American war excitement, when he conceived the proposi-

H. M. FLAGLER

tion of making traffic communication between the United States and Cuba more practical. To him it seemed that such an extension was the logical climax of his work in Florida. He fully saw the importance of Key West as a link in his system, and it appealed to him, not as a money-making plan, but as such a climax to his Florida development work.

In 1905, when the blue prints called for by Mr. Flagler were submitted to him by engineers, he glanced at them, turned to Mr. R. J. Parrott, vice-president and manager of his extensive railway system and his right-hand man in all his Florida undertakings, and asked, not if the extension would pay, but said:

"All I want to know is whether the road can be built."

"It can!" promptly replied Mr. Parrott.

"Then go ahead and build it," was Mr. Flagler's direction.

Mr. Parrott went ahead, and it has been his master hand that has guided this mammoth engineering work through all obstacles to its successful completion. Mr. Parrott was well fitted for such an undertaking. His boyhood was passed in the little town of Oxford, Me., and he was a born railroad man, though it was not until 1889 that circumstances proved him as such. Graduating from Yale, where he made a name for himself in the sports that require courage and endurance, and where he rowed in the crew from 1882 to 1885, he entered the profession of the law in Florida, and in 1888 he became counsel of the Jacksonville, Tampa & Key West Railroad. In 1889, when that road was merged with the Florida Southern, he was its general counsel, and in 1890, when the combined systems went into the hands of a receiver, Mr. Parrott was appointed receiver; and in the handling of the Florida Southern System Mr. Parrott gained his first experience as a practical railroad administrator. In June, 1892, he resigned his receivership and became vice-president and general counsel of the Flagler road. Since that date Mr. Parrott has been prominently identified with railroad extension and operation in Florida, and so well pleased was Mr. Flagler with the work of "that man Parrott" that he made him vice-president and general manager of all his vast Florida undertakings.

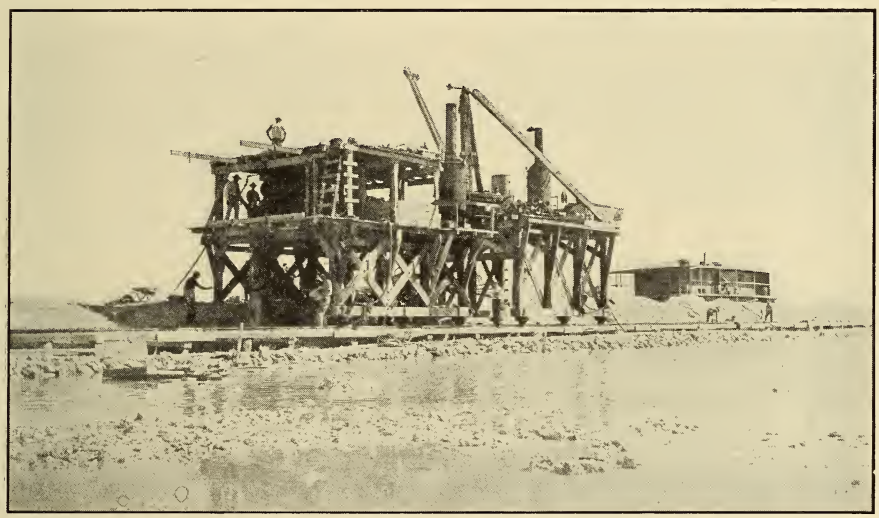
This was the man to whom was entrusted the organization of the construction forces for this railroad across the sea—no simple undertaking, and one which presented many unique features; for instance, the figuring of the effect of hurricane winds and waves on the bridges and tracks and the building of the latter to withstand them.

Mr. J. C. Meredith was selected for constructing engineer; and well he did his work, to which he showed such devotion that he died in service and was succeeded by William J. Krome.

Dredges were soon put to work, eating their way through the 17 miles of swamp between the mainland and the nearest Key and piling up a railroad embankment as they went. For 49 miles the dredge work continued, as many of the Keys were coral ledges just above the ocean's surface. The entire work, due to the character of its surroundings, was most unusual—in fact, it has been rightly called "A web-footed proposition from start to finish."

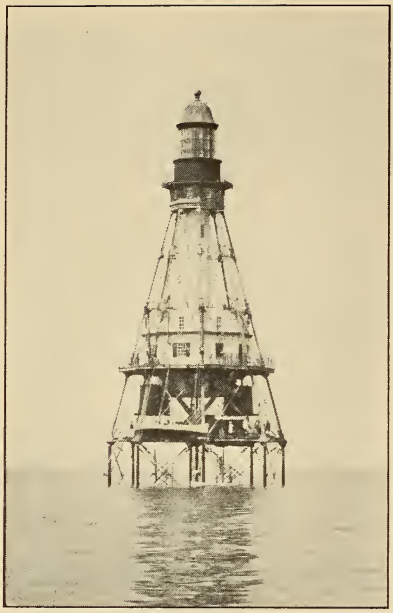
Labour, too, was hard to get; men were not enticed by heat and mosquitoes and the company's rule, that there should be no whiskey in the labourers' quarters, which, owing to the distance of Key West and Miami, they were able to enforce. When it is said that though less than four thousand men was the average number employed in the work, twenty thousand were carried down to the Keys during the first three years, the difficulties of the labour problem will be understood.

Steadily the work progressed, however, now across reefs far enough above the water so that their coral and limestone could be blasted and piled up as in ordinary railroad construction, over shallow water bridged by suction dredges and their ramparts rip-rapped with rocks, through open water, a stretch of 4 miles by means of a trestle to be filled in later, by means of a solid reinforced cement viaduct of 186 massive arches stretching across the blue water for more than 2 miles, with no land save the many Keys in sight. These concrete viaducts are one of the most interesting portions of the work. They are built in water from 10 to 30 feet deep, which in most places is exposed to the full gales of the Atlantic. The concrete at times, after being mixed in barges, was placed in position by powerful boom derricks; again, molds were formed by driving piles to hold the watertight framework in place. Sometimes caissons had to be sunk or cofferdams built, but steadily and permanently the line grew southward, practically jumping from Key to Key, as the longest stretch of track on any of the Keys is but 16 miles.



TRAVELING CONCRETE MIXER FOR CONSTRUCTING VIADUCT ON THE FLORIDA EAST COAST RAILWAY

Seven miles of almost unbroken



LIGHTHOUSE ALONG THE KEYS

open water had to be crossed between Knight's Key and Bahia, Hunda. This was covered by bridges, divided into four sections, a total length of 35,815 feet. Three of these are concrete piers with steel girdle spans, to carry the track, the fourth composed of arches of reinforced concrete. After this there were ten other gaps to be crossed, varying from a mile in length to shorter distances.

The viaduct at Long Key, nearly 7 miles long, used up 286,000 barrels of cement, 177,000 yards of crumbled rock, 108,000 cubic yards of sand, 612,000 lineal feet of piling, 5,700 tons of reinforced rods and 2,600,000 feet of dressed lumber for arch forms.

The usual method of building a railroad embankment was reversed, the rocks being put in first and afterwards protected by a heavy layer of marine marl dredged from deep deposits nearby. The latter material is pulverized coral, a clayey substance, which was applied in the form of a very soft mud, but which when dry became a solid homogeneous mass, which proves very resistant to wave action, being, in fact, a sort of natural cement.

In all cases the track is placed far above high-water mark, so that there may be no fear of temporary inundation. Money had not been spared in any portion of the undertaking, cuts and fills are wide and substantial, and all work has been done in the most lasting manner.

This new road, which cost $150,000 per mile—the record for single-track construction—makes Key West a part of the mainland for all practical purposes; and the harbour of Key West will become one of the most important in the United States after the opening of the Panama Canal, located, as it is, on the direct new artificial artery of commerce.

Cuba and its enormous wealth of tropical products are brought by it

MARL PIT TRESTLE AND DREDGES WHERE MATERIAL FOR PROTECTION OF SLOPES OF EXPOSED EMBANKMENTS IS OBTAINED. KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

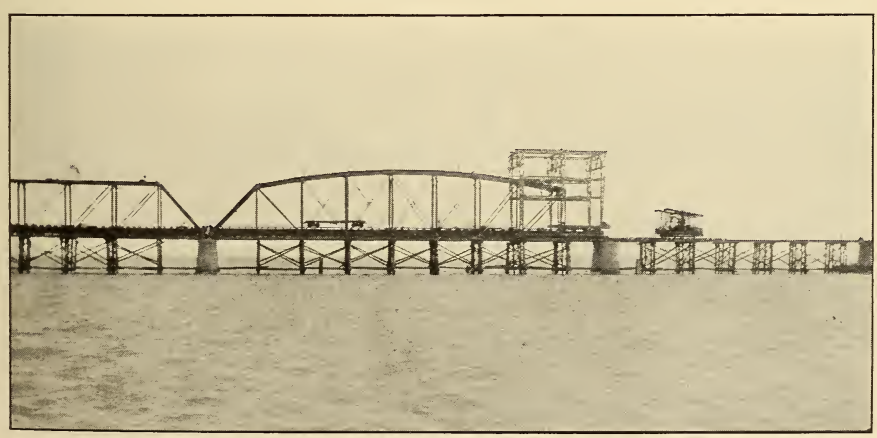
BAHIA HUNDA BRIDGE, ONE MILE IN LENGTH, WITH DEPTH OF WATER 30 FEET. KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

into direct railroad communication with the markets of the United States, and three years from now, when the Panama Canal is a reality, this rail route from the mainland of Florida to Key West, which will be the nearest railway terminal to Panama and the great cities of South America and their vast resources, will be a most important link in rapid communication with Western South America and beyond; and Key West will, without doubt, become not only an industrial centre, but also a military and naval base of the greatest strategic importance.

This extension forms the last link at the south of the great through-railway service along the Atlantic Coast with South America and Central America, and it is one of the greatest feats of American engineering skill, of American enterprise and grit, and is in importance second only to Panama as an engineering feat.

At Key West, docks 1,900 feet long have been constructed. Eighty acres of fill are now completed and 75 acres will be added to this in the near future, making land for terminal purposes where only a few years ago the natives gathered sponges along the shores of Man-of-War harbour.

The total cost of this sea-going railway has been $20,000,000, considerably more than the estimates of



BAHIA HUNDA BRIDGE SPAN OF 243 FEET UNDER ERECTION, KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

BOCA CHICA VIADUCT ON THE KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

eminent engineers when the work was first planned. Engineering problems hitherto unsolved were encountered. Fills were made in a day, only to disappear overnight, and unfinished work of months was swept away in one full hurricane. Many men would have given up the struggle against the unforeseen and the elements, but Mr. Flagler had faith in Mr. Parrott's ability and continued the work.

Engineering problems were not the only obstacles encountered in the construction of this railway. Among the thousands of labourers who were sent to the construction camps on the Keys were hundreds of hobos, ex-convicts and the riff-raff of Philadelphia, Boston and New York. This element accepted transportation to the camps with no idea of work. They expected to drop from the train along the way and spend the winter in a warm climate. The first few hundred succeeded in doing this, but soon the authorities of every State below Maryland had the trains policed, and Mr. Hobo found himself in a construction camp on one of the many Keys between Miami and Key West. Next morning he went out with one of the gang, and by shirking his part of the work was soon spotted by the other labourers, who had to carry his share of the weight in moving heavy timber. They soon made life unpleasant for him, and, finding he could not remain in the construction camps without work, he took the boat back to Miami, with the idea of turning tramp for the rest of the winter and then beating his way back North. On arrival at Miami, after an enforced abstenance from beer, as it was not permitted on the Keys, he got good and drunk, made a disturbance, and was sent to the chain gang for thirty days, where he worked on the rock piles under armed guides. His time up, he wrote long letters to the newspapers in the North how he and other labourers were being held in slavery by Flagler. The press was full of it until they sent representatives to make investigations. Meanwhile, Mr. Flagler had been indicted for peonage. After the newspapers, through their special correspondents, learned the truth, they were profuse in their praise of the kind-hearted old man who was turning the east coast of Florida into a paradise. Some of the papers that had called him a slave-owner said he was the only man in the Standard Oil crowd that

deserved any credit for his life-work, and others stated that had he—Mr. Flagler—constructed the sea-going railway in any other country in the world the government would have subsidized it and given him a vote of thanks. When the case came to trial it was practically abandoned.

The extension of the Florida East Coast Railway will always remain a monument to the memory of H. M. Flagler, the man who had faith in the word of another man, and whom he rewarded by making J. R. Parrott president of his railway and all his Florida interests.

THE NEW BUSINESS CENTRE OF THE UNITED STATES

By A. E. Stilger

(Concluded.)

IN the previous articles of this series attention has been directed to the remarkable growth of the Thirty-fourth street section of New York City, as indicated by the extent to which the older buildings have been replaced by modern business structures of immense size devoted to all departments of industry; to the phenomenal rise in real estate values; to the establishment of financial institutions in the midst of the district, and to the selection of this portion of New York for the great terminal station of the Pennsylvania Railroad system.

The manner in which a commercial district is advancing may be better perceived while the changes are taking place than after all the old landmarks have been effaced by the demands of business. This fact has been emphasized by the illustrations which have been given, showing the portions about the new Pennsylvania station which are as yet unimproved and which, remaining in the condition in which the greater part of the section was a score of years ago, indicate most clearly the magnitude and nature of the immense change which has already taken place. The parting of the ways is very clearly shown at the intersection of Madison avenue and Thirty-fourth street. Looking westward from this point the eye is held by the continuous stretch of business buildings, repreenting every conceivable line of effort, mercantile, manufacturing, professional, many of them imposing structures, and all filled to the limit of their capacity. Turning to the eastward, one is immediately impressed by the marked contrast, there being but few business places and a great preponderance of private residences.

Here, then, is the line for immediate development. Property on Thirty-fourth street, be it East or West, is far too valuable to be used for residential purposes. At the eastern end is the Long Island ferry, while at the western portion stands the Pennsylvania terminal, connecting with the cities and towns of Northern New Jersey. The obvious advantages of this line across New York, extending between the two vast home centres of the commercial metropolis and holding, at the same time, the central position between the crowded lower city and its rapidly growing upper

part, are apparent; and its stupendous opportunities as a commercial location must be clear even to the most casual observer.

The surest way to conserve the present advantages of this location is to provide the facilities required by the demands of business. We have already affirmed that property on Thirty-fourth street is too valuable to be used for residential purposes when it is situated in such a business centre, capable of utilizing blocks of modern commercial buildings. All through the district there will be seen portions of blocks awaiting conversion, some portions west of the Pennsylvania terminal to the manufacturing district and the steamship wharves being in the same unimproved condition as exists in the eastern section.

An obvious defect in the development of New York appears in the fact that improvements are made in piecemeal fashion, so that we often see a magnificent structure and a hovel side by side. A far more efficient method is found in the preparation of a definite plan for improvement, a section or a street being improved according to a well-defined scheme, providing for demands along its entire extent. In the business of banking all interests are mutual, one side not being benefited more than the other. The people require secure investment for money, while the bank owes its existence to the fact that it can and does make money and valuables safe under modern methods of protection. In like manner all business ventures, falling in with the spirit of the time, must be so ordered and managed as to tend not merely to the benefit of a corporation or individual concern, but to the advantage of the people as a whole. When any need arises it is to the advantage of all to meet it.

The needs of the district at present are several. A subway on Seventh avenue would still further enhance the value of the neighbourhood, providing access and transport and relieving congestion. With the incoming of additional crowds there should be provided additional police protection, the municipal development keeping pace with the needs of the people and the banking and commercial businesses as they are being developed.

It has been said that if one's grandfather had had the foresight to purchase a farm on the site of Thirty-fourth street the grandson would be a millionaire to-day. In the past it required the progress to the third generation to enable such advances in value to be realized, but at the present time changes are so rapid that such increases may be perceived in a decade or less. It requires only the prophetic vision to look ahead a short distance so that a man may grasp the golden opportunity for himself and not for his remote descendants. What the future may hold for our followers no man may venture to tell.

Summing up this review of the new business centre, with reference to its especial and immediate needs, particular emphasis may be laid on the following points:

1. Increased transportation facilities;

2. Utilization and beautifying of unoccupied spaces;

3. Co-operation and interest of surrounding neighbourhood;

4. Construction of additional office and loft buildings;

5. Construction of a subway on Seventh avenue;

6. Reduction in passenger and freight rates.

The immense advantages which the district offers should form an incentive to corporations, business men and propertyowners to make the future development far greater even to that which has already taken place. This new business centre opens the gateway to a region of unequaled prosperity in the form of ample returns upon business enterprise and foresight. Only concerted effort is needed.

HILLSIDE DWELLINGS FOR WORKINGMEN

By Sherrard Ewing,
Assistant Secretary, Pittsburg Civic Commission

PLAN A.—FRONT VIEW OF ROW OF HOUSES FACING STEPS AND TERRACES BETWEEN STREETS X AND Y

The streets are 92 feet apart. These houses are only one room deep. They would have a window open into every room and in the upper floor an extra window on the lower side.

THE place of engineering achievement in any amelioration of the housing problem of large cities is emphasized in a recent report on "Hillside Dwellings for Workingmen," issued by the Pittsburg Civic Commission. In a measure, the Pittsburg contribution to the study of housing conditions serves but to illustrate the truth of Charles E. Heitman's statement in CASSIER'S for December that "the question of how best to house the people of our great cities . . . . bears such close relation to and is so dependent upon what is mechanically possible that it almost resolves itself into strictly a mechanical problem."

Pittsburg, because of peculiarities of topography, making narrow, level strips along river banks extremely valuable for railroad and manufacturing uses, has been forced to turn her eyes to the steep hillsides abutting on mill districts. Her workmen are confronted by the alternates of living in greatly congested areas or of daily paying street-car fare to distant points.

It has been realized that the "invention" of a method by which the typical Pittsburg hillside of a 50 per cent. grade could be utilized on a practical basis as the site for modest homes, while not solving, would at least improve housing conditions in that industrial centre. Such hillsides are within easy walking distance of several of the city's mill districts and of the downtown business section. They are at present, with their barren slopes, ugly features of the landscape not fit for the pasturage of goats.

To solve the mechanical problem presented, architects, builders and

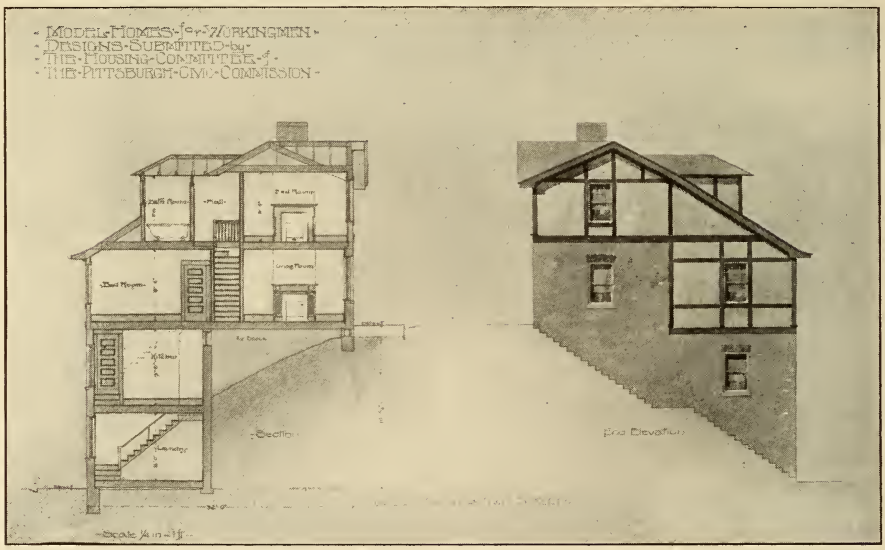
real estate and supply men comprising the membership of the housing committee of the Pittsburg Civic Commission spent two years in drawing up, considering and throwing away plans. Finally, a unique hillside treatment has been devised which gives promise of standing the test of practical demonstration. Although planned for a particular location—Sohohill—the treatment is applicable to any similar site.

House plans are of two distinct types. One (plan B-1) is for streets encircling a hill. This calls for horizontal rows of small houses, fronting on two streets only 32 feet apart, but one on a considerably higher level than the other. The other scheme (plan A-1) is for double rows of attached houses, back-to-back and fronting on terraced ways running up and down a hill, the terraced way being intersected at right angles by streets. Foundation walls would serve as retaining walls for the hillside. The circumferential streets would be so connected with the city street system that the occupant of a house could go to work by way of the street on the level below his home and return on the street above, thus avoiding the climbing of long flights of steps.

The originality of this second arrangement of building sites makes it the most striking feature of the report. Houses would front on a more or less private way, made up of terraces and flights of steps leading above and below the circumferential streets. Little space is given for yards, the plan being that a tract at the top of the hill would be reserved for a children's playground and a recreation park for adults.

Fortunately, because of the steep slope of the site, it is possible for each house to have windows on the lower side admitting light and air to the upper floor, thus obviating the objection to the ordinary row of houses with windows on one side only, that they are simply pockets of dead air.

Accompanying illustrations explain the scheme for hillside treatment more clearly than it can be described in words. A competent critic has said of this report: "A real appraisal of the constructive ingenuity



PLAN B.—END VIEW AND VERTICAL SECTION (REVERSED) OF A HOUSE FRONTING TWO STREETS

Sectional view shows arrangement of two bed-rooms, living-room, kitchen, laundry, and bath-room, with ample window space in every room.

PLAN A2.—SIDE VIEWS OF HOUSES AT UPPER END OF ROWS

These houses face on a way made up of steps and terraces connecting street levels. The view shows four houses built in pairs, back to back, each house one room deep.

of these plans in securing a household footing on the slopes back from the mill and commercial sites along the rivers can best be appreciated by those who have seen the topographical difficulties which Pittsburg presents."

Issuance of the report was followed immediately by evidences of the interest in such plans of officials of great steel and coal companies employing hundreds of men whose proper housing has become one of the problems inseparable from big business. Voluntary organizations of many cities are striving to adapt the fundamental ideas of the plans to their own conditions. The Pittsburg report, although not the final word on the subject, will probably prove of great value in giving impetus to study in the right direction and in emphasizing the value of the co-operation of high engineering or technical skill with disinterested civic endeavour.

PLANS A AND B. PROFILE SHOWING TREATMENT OF ENTIRE HILLSIDE

Description, left to right: Apartment house; end views of two rows of houses (Plan B) fronting on two streets 32 feet apart; front views of houses facing steps and terraces between streets (Plan B) showing blocks of four or three houses between circumferential streets 92 feet apart.

EXPANSION WITHIN THE UNITED STATES

THE approaching completion of the isthmain canal and the transformation in trade routes and commercial developments which must follow in its wake unite in calling attention to some of the features of certain portions of the United States which, by nature and location, are connected with these impending changes.

The older countries of Europe are seeking opportunities for expansion to find the means for meeting the pressure of growing population and developing industries, while, at the same time, they are dependent upon outside resources for a portion of the supply of the necessaries of life. France and Italy are reaching out into Northern Africa, while Germany is endeavouring to get whatever territory may properly be secured to meet these demands. These things are subjects of political discussion and form leading topics in the current newspapers and magazines, while little is said about the vast areas of fertile land yet available for development within the limits of the United States.

The single State of Texas, for example, is of greater area than France or of the entire German Empire, the figures being, in round numbers, about 204,000 square miles for France, 209,000 square miles for the German Empire and 262,000 square miles for Texas. Thus it will be seen that either of these great countries of Europe might be placed in the middle of this single one of the United States, with ample margin all around.

Of this great State, the most important river is the Rio Grande, forming the boundary between the United States and Mexico and draining an area of 250,000 square miles, bringing fertile soil down to its lower valley and rendering it a most desirable agricultural region.

Texas has passed through the natural sequence of many other parts of the country in the development of its natural resources. Its great plains formed ideal regions for grazing, and the cattle ranges of Texas are still associated in the minds of many with its principal industry. Then came the sub-division of areas into agricultural districts, and Texas has become the leading cotton-growing State of the Union, while general agriculture followed. With the development of mineral resources and the exploitation of its oil fields and with the spread of railway communication, the State has fairly entered upon a career of general commercial and agricultural exploitation which is scarcely appreciated except by those who have come into immediate contact with it.

The extent to which this agricultural development has taken place may be seen by a glance at the official figures given by the United States Department of Agriculture, these showing that the value of Texas corn per acre exceeds that of Iowa, Kansas or North Dakota; that the wheat yield leads that of Iowa, North Dakota, or Illinois, in value per acre; that the yield of oats is ahead of Iowa, Illinois or Wisconsin; in barley it leads Illinois, North Dakota or Minnesota; in Irish potatoes it is far ahead of Iowa, Illinois or North Dakota, and that in sugar cane Texas leads the important States of Louisiana, Florida or Alabama.

Thus, compared with States which are well known for their successful development in various departments of agriculture it appears that conditions in Texas are most favourable.

UNITED STATES MILITARY ROAD IN TEXAS

It is natural to compare a Southern State like Texas, in its agricultural and commercial possibilities, with such States as Florida or the southern portion of California, and, in part, such a comparison may be correctly made. It is necessary, however, to remember that, while the soil of the lower Rio Grande Valley is equally fertile with that of Southern California, it is also available for the great staple crops of cotton, corn and sugar cane, all having assured markets and definite commercial means of handling.

So far as agricultural purposes are concerned, the farmer in Texas renders himself practically independent of rainfall conditions by the employment of irrigation, obtaining the supply of water from artesian wells, the success of which has been so amply demonstrated as to leave no doubt as to the availabil-

ARTESIAN WELL SUPPLYING WATER FOR 160 ACRES

ity of this method of controlling crops. With the fertile soil of the valley and the wholly controllable water supply, the question of success is dependent wholly upon industry and ability and is taken out of the realm of uncertainty.

The extent to which the development of Florida and of Southern California has been aided by natural attractions to the visitor is well known, and there is every reason to believe that the Gulf Coast of Texas will follow closely along similar lines. In many ways the Gulf of Mexico resembles in these respects the Mediterranean, and with the opportunities for bathing, fishing, hunting and motoring, not to speak of motor boating, it is apparent that there is here a region for recreation, rest and recuperation which will go hand in hand with the commercial and agricultural development.

Transportation facilities already offered by existing railroad connections will be still further extended upon the opening of the Panama Canal, the opening of the deep-water harbour and the building of the Mexican Railway cut-off and development of the 'Frisco system.

Returning to the comparison which was made in opening, the great countries of Europe are reaching out for opportunities to extend and to provide new opportunities for their people to take up agricultural lands and create markets for industrial products. In the United States there is no need to look beyond existing boundaries for such opportunities. Anyone who has visited Holland knows what can be done by the in-

GRAPE CULTURE IN THE RIO GRANDE VALLEY

SOME TEXAS CABBAGES

HOW CORN GROWS IN TEXAS

dustrious and intelligent farmer with fertile land and opportunity for cultivation, and understands how one of the most densely populated countries in the world may also be one of the most prosperous and freest from poverty. Anyone who has seen how the climatic attractions of the Riviera, of Cairo and of Florida have drawn wealth and activity, will also realize how such conditions in other parts of the world may be directed toward the development of the highest kind of prosperity.

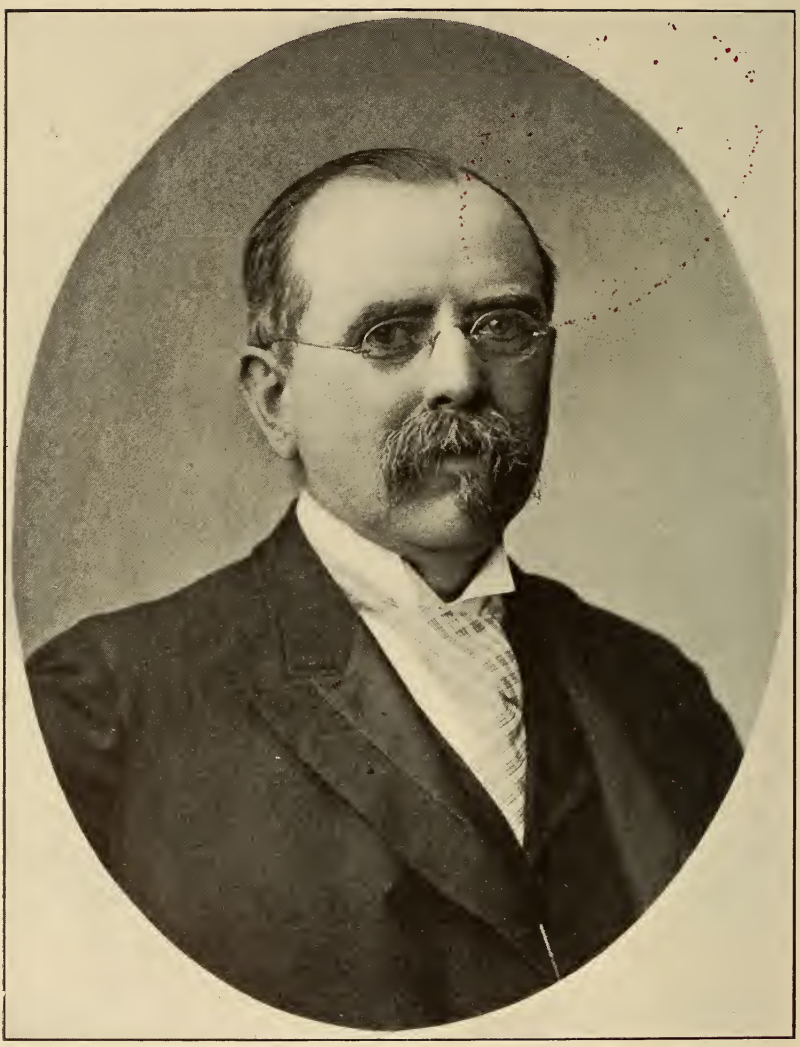
When, however, the opportunities, both for agricultural expansion and for resort development, appear side by side in the direct line of one of the greatest of modern engineering undertakings, it will be seen that it is necessary only to profit by the lessons of the past.

The approaching completion of the Panama Canal, and the extent to which it may be expected to develop trade between the United States and the western coast of South America, make it desirable to recall the life and work of the man who did more than any one individual to build up successful commercial relations between North and South America—the late William Russell Grace.

Born in the early thirties of the nineteenth century near the city of Cork, in Ireland, and soon taking to a seafaring life, young Grace went to Peru with his father, and, although his parent soon returned home, the boy remained, and, after occupying various positions, became connected with the firm of Messrs. John Bryce & Co., of Callao, Peru, of which he ultimately became a member, the name of the firm becoming Bryce, Grace & Co. In 1860, by the time Mr. Grace had been for ten years in Peru, the company had become one of the most prosperous on the West Coast, and was taking a leading part in Peruvian affairs. The firm later became Grace Brothers, a younger brother, Mr. M. P. Grace, entering the concern. During the civil war in the United States, Mr. Grace rendered valuable service in connection with the furnishing of supplies to vessels of the United States Navy at the port of Callao. In 1865 he came to New York, and founded the firm of W. R. Grace & Co., now the leading concern engaged in South American commerce, interested not only in merchandising, but also in the development of shipping, manufacturing, street railways, electric lighting and railway construction, the latter including the famous Lima & Oroya Railroad, the Bolivia Railway, the Transandine Railway, and other important transportation enterprises.

Mr. Grace was connected with various business concerns in the United States, being President of the Ingersoll-Sergeant Company, etc., and serving twice as Mayor of New York City.

Upon his death, in 1904, he was succeeded as President of the W. R. Grace & Co. by his son, Mr. Joseph P. Grace.



Photograph by Aime Dupont

WILLIAM R. GRACE

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POTASH DEPOSITS IN AMERICA

By Guy Elliott Mitchell, U. S. Geological Survey

IT is an interesting fact that any attempt to monopolize a natural resource of industrial value is almost sure to be met by investigations of explorers which reveal other sources of supply. In nearly every instance those deposits of mineral substances which are immediately required and are directly available, are utilized, so long as no attempt is made to demand exorbitant prices, or impose onerous conditions. When, however, monopolists, feeling certain of their control of the supply of something which the rest of the world cannot do without, endeavor to hold prices beyond the legitimate commercial profit, and when governments use such assumed monopolies to demand concessions otherwise not easily obtained, the natural result appears; and all the resources of applied science are brought to bear to break the monopoly which is thus sought to be abused.

A noteworthy example of these economic truths appears in the present condition of the situation with regard to the supply of potash salts; essential elements in the maintenance of agricultural success. Potash is an absolutely essential constituent of any complete fertilizer, and a supply of potash salts is necessary for the maintenance of the fertility of soils in which modern agriculture is conducted. For agricultural purposes, however, potash exists in only a limited area, so far as existing commercial conditions understand it. The only available supply of potash salts for agricultural purposes is that in the Stassfurt deposits in Germany. Presuming upon this fact, the owners of the German deposits, supported by the German government, have assumed that the possession of this immensely valuable monopoly warrants the imposition of conditions which are impossible of acceptance, both from an industrial and political point of view. The natural consequence has been a systematic investigation, on the part of the United States Geological Survey, to examine the possible sources of supply within the limits of the United States, in order to obtain absolute release from the attempt of a foreign organization to control a matter upon which an internal industry was dependent. The success with which these efforts are likely to be crowned will show the lack of wisdom which has permitted the immediate advantage of the German monopolists to be pressed, and there is every reason to believe that before long the entire American market will be lost to those who might have retained it

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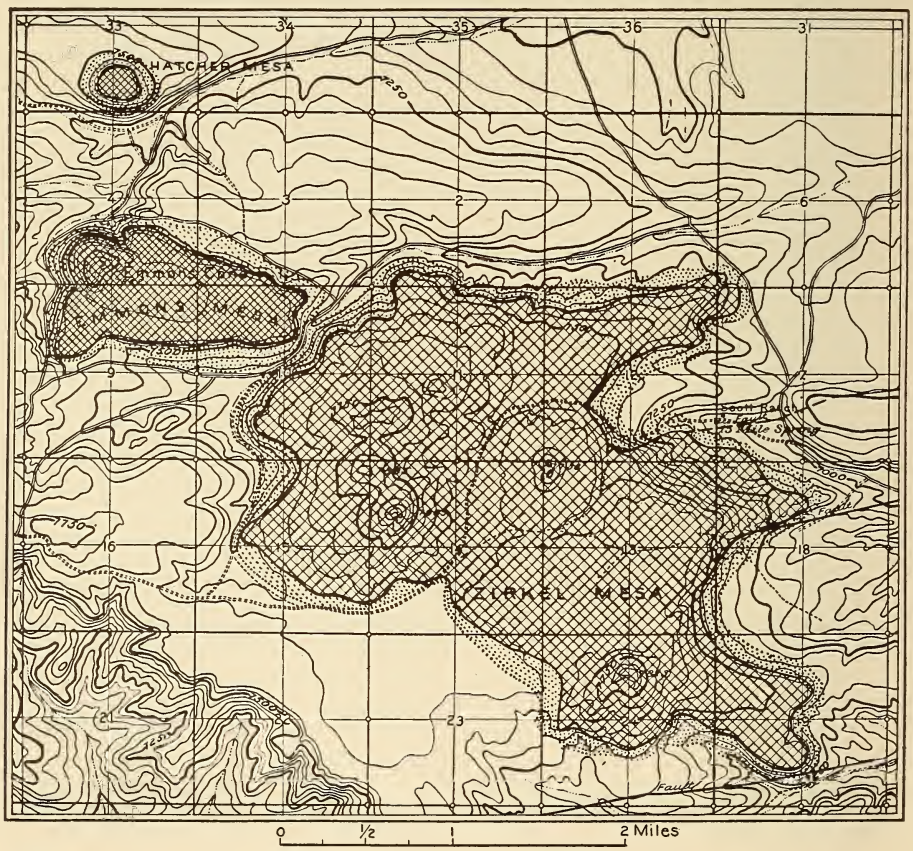
if they had been satisfied with a reasonable margin of profit and an absence of political intermeddling.

The extent to which the German potash monopoly has stimulated the investigations into internal sources of supply will be realized when it is understood that in the year 1900 the imports of German potash into America amounted in value to $4,000,000; that in 1910 the amount reached more than $11,500,000, and that, according to the customs returns for 1911, as estimated by the Bureau of Statistics of the Department of Commerce and Labour, the imports for last year show a value of nearly $15,000,000, or £3,000,000. When it is understood that a large portion of the grain produced in America goes abroad, and that all the potash which must replace the constituents which it draws from the soil must thus be imported, the desirability of developing an internal source supply of potash fertilizer will be realized.

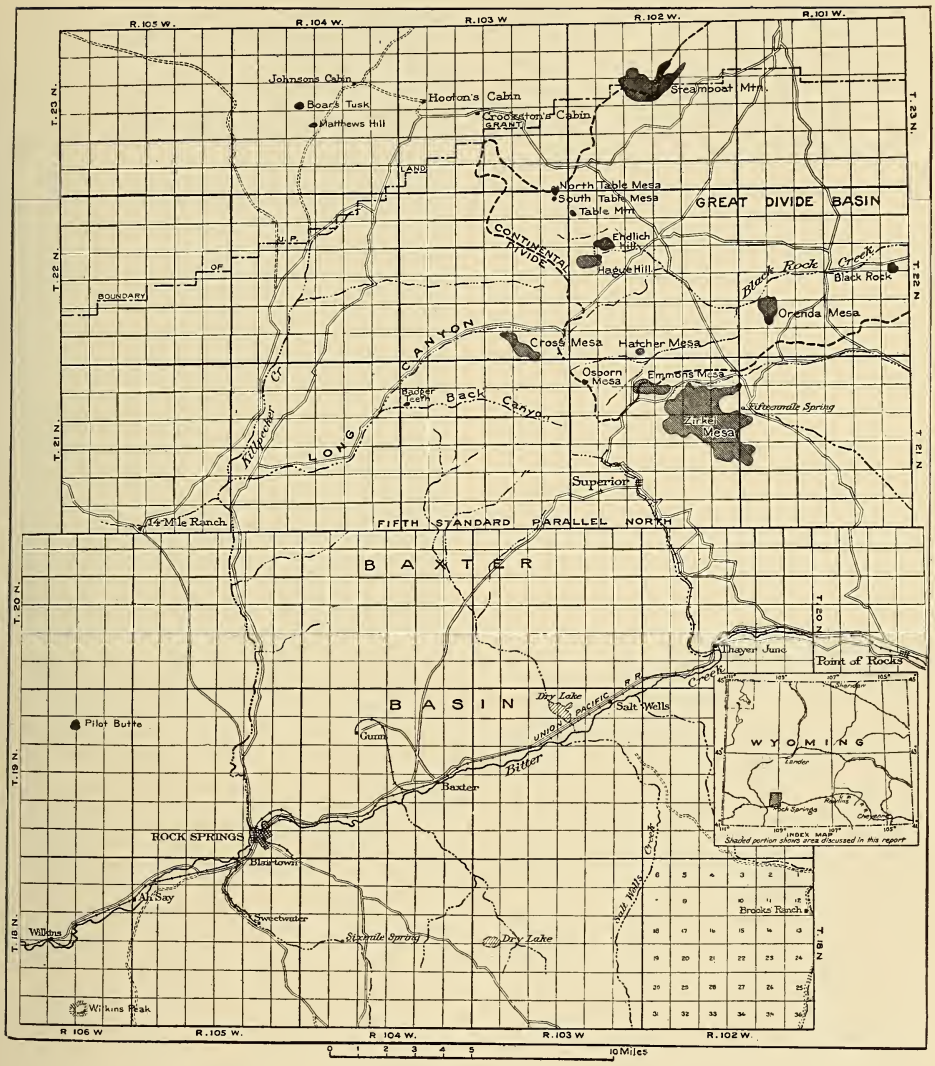
It is well known that the granites and feldspar rocks contain enormous amounts of potash, but in this form it is insoluble and unavailable for use as a fertilizer. There is, however, in the leucite area of Wyoming, the potash-rich rock of Zirkel Mesa, from which it is hoped that a process for commercial treatment is being evolved, which will solve the problem, and render the United States independent of the overbearing German monopoly.

Already the American Potash



MAP SHOWING LOCATION AND TOPOGRAPHIC RELIEF OF ZIRKEL MESA

Cross-ruled areas represent lava in place; stippled areas, distribution of lava fragments



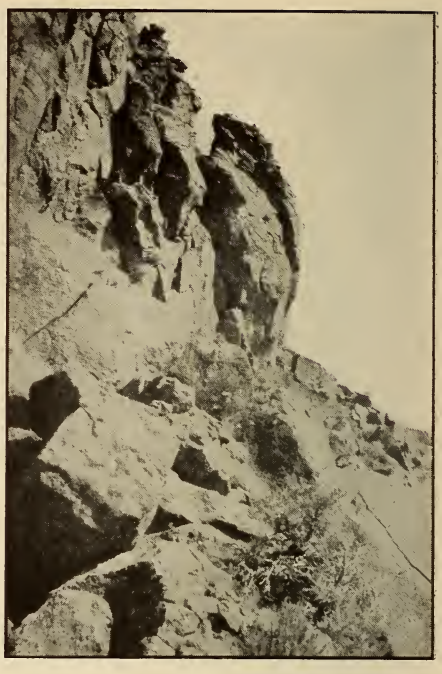
MAP SHOWING LOCATION OF POTASH-BEARING ROCKS OF THE LEUCITE HILLS, SWEETWATER CO., WYOMING

Shaded areas represent exposures of leucite-bearing rock

Company, of Denver, claims to possess a process for commercially treating the potash-rich rock of Zirkel Mesa in the leucite area of Wyoming, producing therefrom a commercial potash supply, and this lends special interest to a report now being issued by the United States Geological Survey descriptive of the chemical composition and extent of the rocks of the Leucite Hills and containing an estimate of the leucite-bearing rock "in sight," with the approximate tonnage of potash which these rocks may yield. This yield is of course dependent upon the feasibility of the Denver company's process, or of some other process, for the extraction of the potash, since leucite is what may be termed a refractory rock, and no process has yet been developed and applied for liberating the potash from this or other potash-bearing rock on a com-

mercial scale. The American Potash Company claims that its proposed treatment of the leucite rock is, however, commercially feasible, and if this is a fact, the Survey's conservative estimate of nearly two billion tons of rock, carrying 10 per cent. or upwards of potash (K_2O), indicates a great potential value to these deposits and at the same time shows as available an important native source of potash for supplying the United States with this fertilizing material for which we are now entirely dependent upon Germany.

The practicability of commercially treating the leucite-bearing rocks of Wyoming is viewed by A. R. Schultz and Whitman Cross, authors of the Geological Survey report* referred to, with the conservatism characteristic of the Survey, the extraction of all the potash from these rocks involving, according to the report, the dissociation of the potash from at least three minerals—leucite, phlogopite, and sanidine. It is also pointed out that any enterprise proposing to utilize these lavas for the establishment of a source of potash should not overlook the fact that German potash now commands a price much in excess of the cost of production, including all exporting and transportation charges. This wide margin of profit makes possible extensive reductions in the present prices, which might cripple or even destroy all chances of success for any competitor entering the field under present conditions. At the same time geologists are of the opinion that investigation of leucite rock offers a highly attractive field for the technologic chemist, industrial engineer, and experimenter, due to the fact that leucite is, undoubtedly, less refractory than feldspars and most other potash-rich rocks, and also because of the enormous available tonnage of these leucite deposits. Be these conditions as they may, the report of the Geological Survey is most timely in that it makes public, accurate data regarding the leucite area, the tonnage, potash and alumina content, and location, and indicates which deposits are on public and which on private lands, while it does not minimize the difficulties attending the extraction of the potash from this more or less refractory lava.

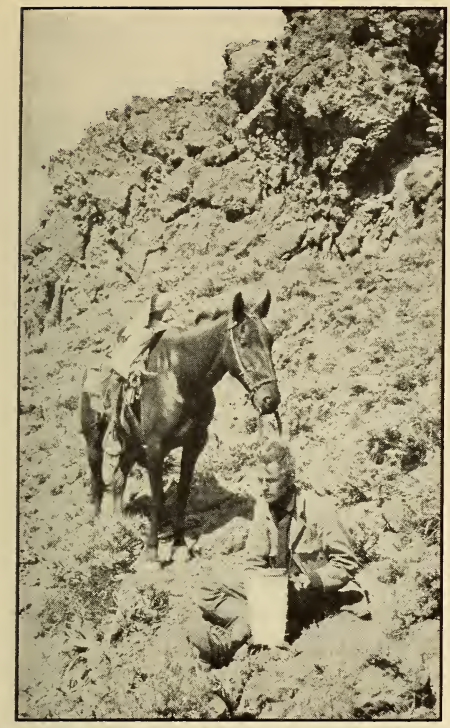


LAVA FLOW ON CROSS BUTTE, LEUCITE HILLS, WYOMING

The Leucite Hills of Wyoming, located in the Rock Springs coal district, have long been known among geologists as interesting examples of volcanic outflows of an unusual lava. An examination of the area was made by Cross in 1884, followed by a careful study, describing in exact terms these exceptional rock types, which at that time held only scientific interest.

More than half a century ago Von Humboldt published the conclusion that leucite was a mineral found only in Europe, and while it has since been recognized in many lava flows in other countries it remained for the geologists and petrographers

* Bulletin 512, Potash-Bearing Rocks of the Leucite Hills, Sweetwater County, Wyoming.



PART OF CRATER CONE, SHOWING IRREGULAR ROUGH LAVA FRAGMENTS AT CROSS BUTTE, LEUCITE HILLS

of the Fortieth Parallel Survey to prove the existence of leucite-rich rocks in North America—the discovery of the Leucite Hills by the late Samuel S. F. Emmons in 1871, and the subsequent description by Zirkel* from whom the largest deposits, Zirkel Mesa, was named. Subsequent examinations of the area and discussions were made by Endlich† of the Hayden Survey, and Powell‡ in his geologic explorations of the Unita Mountains. Later examinations and publications were made by Whitman Cross and A. R. Schultz of the United States Geological Survey, and by J. F. Kemp and W. C. Knight. The present report of Schultz and Cross is not the result of new but of old work, and the facts are presented so that authoritative data on this possible potash resource may be readily available. There are but two other localities in the United States where leucite-rich rocks are known, namely, in the Bearpaw and Highwood Mountains of Montana, the rocks of which have been described by Weed and Pirsson in United States Geological Survey Bulletin No. 237. The Montana rocks, however, are not so rich in potash as those of the Leucite Hills, Wyoming. The lavas of the latter contain on an average a somewhat larger percentage of potash than any known igneous rocks.

The lavas of the Leucite Hills are all very fine grained, rather earthy looking rocks, showing to the naked eye only reddish-brown mica flakes. The rocks vary in color from a dull reddish or yellowish-gray to straw color, and leucite has been detected only with the aid of the microscope. Nine analyses are given in the report, the potash content of the rock in five of them running more than 11 per cent., the highest being 11.91 per cent., or practically 12 per cent., with an average of 10.74 per cent.

ELKHORN MONUMENT ON YEUKEL MESA MADE FROM FRAGMENTS OF THE LEUCITE ROCK
This mesa contains 104,000,000 tons of potash

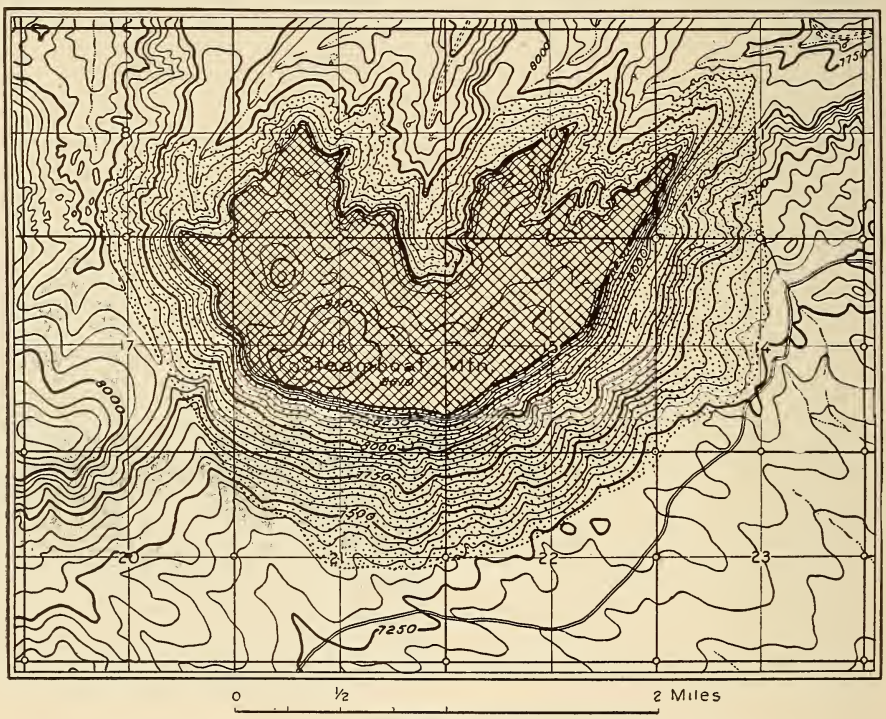
* Zirkel, Ferdinand, Rept. U. S. Geolog. Expl. 40th Parallel, vol. 6, 1876.
† Endlich, F. M., 11th Ann. Rept. U. S. Geol. and Geog. Sur. Terr., 1877, 1879; 12th Ann. Rept., 1878, 1883.
‡ Powell, J. W., Geology of the Unita Mtns., U. S. Geol. and Geog. Sur. Terr., 1876.

Small deposits of almost pure nitre or potassium nitrate are also described as having been found in a portion of the leucite area. Commercial nitrate deposits would be of equal value with those of soluble potash, but the public is warned of the fact, that while these nitrates are of scientific interest they are found in only certain protected crevices and are of no economic importance.

The leucite lava is described as a recent and somewhat restricted volcanic flow or cappings which rise like monadnocks out of the dissected table-lands, or stand like sentinels from the bottoms of the eroded valleys. Such names as The Boar's Tusk, Badger's Teeth, Pilot Butte, and Steamboat Mountain, suggest the striking character of the formations. Detailed discussions are given of twenty mesas, or buttes, covering an area of approximately ten square miles. The largest of these is Zirkel Mesa, which is estimated to contain more than 104,000,000 short tons of pure potash (K_2O); Steamboat Mountain contains more than 20,000,000 tons; Black Rock Mesa nearly 16,000,000 tons. In all, the Geological Survey's estimate of the potash content of the rocks of the area is 197,349,617 short tons!

The following table is a summary of the available leucite-bearing rock and its potash constituent from the several exposures of the leucite hills. The potash is estimated on the basis of 10 per cent., which is below the average of the analyses made. The alumina (Al_2O_3) content is practically equal to that of the potash.

These figures do not take into consideration the rock that occurs in the dikes associated with the volcanic necks and surface flows, nor the material contained in the necks underlying the mesas, which is not estimated in the report. What actual mining operations would uncover in regard to the size of the volcanic



MAP SHOWING LOCATION AND TOPOGRAPHIC RELIEF OF STEAMBOAT MOUNTAIN
Cross rules represent lava in place; stipples show distribution of lava fragments

BADGER'S TEETH, LEUCITE HILLS, WYOMING

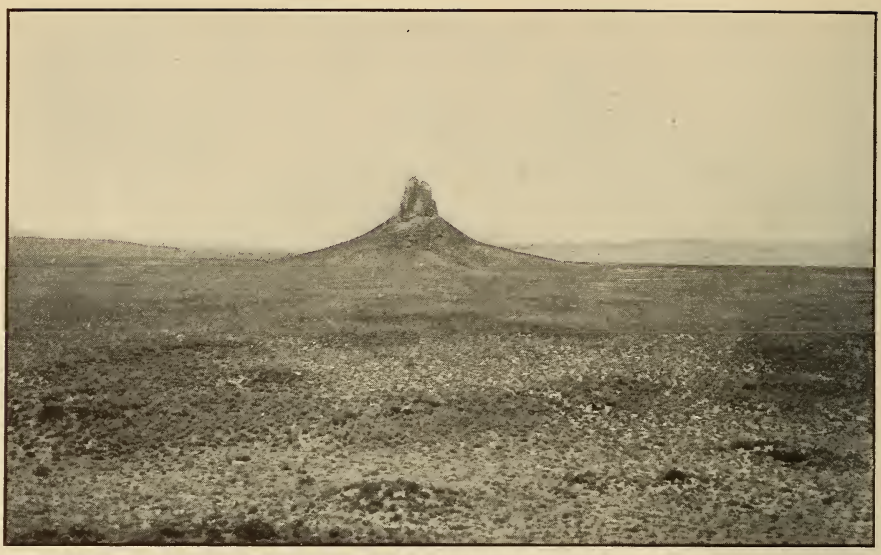
SUMMARY OF THE AVAILABLE LEUCITE-BEARING ROCK, ALUMINA, AND POTASH FROM THE SEVERAL EXPOSURES OF THE LEUCITE HILLS, WYOMING

	Leucite-Bearing Rock, in Tons.	Potash (K_2O), in Tons.
Badger Teeth	17,841,105	1,784,110
Black Rock Mesa...	157,237,200	15,723,720
Boar's Tusk	28,994,384	2,899,438
Cross Mesa	78,732,540	7,873,254
Emmon's Mesa	94,630,000	9,463,000
Endlich Hill	206,584	20,658
Hague Hill	376,712	37,671
Hallock Butte	11,450,970	1,145,097
Hatcher Mesa	5,127,300	512,730
Iddings Butte	11,526,932	1,152,693
Matthew Mesa	17,519,690	1,751,969
North Table Mesa..	15,192,000	1,519,200
Orenda Mesa	149,976,184	14,997,618
Osborn Mesa	5,697,000	569,700
Pilot Butte	6,080,000	608,000
South Table Mesa..	108,774,720	10,877,472
Steamboat Mountain.	206,181,800	20,618,180
Table Mountain	4,177,800	417,780
Weed Butte.....	11,431,980	1,143,198
Zirkel Mesa 1,042,341,276		104,234,127
	1,973,496,177	197,349,617

conduits is a matter of conjecture, but it is certain that before an unminable depth were reached a considerable additional tonnage of "ore" would be developed.

While it is somewhat futile to consider this source of potash with reference to the country's consumption of soluble potash, in advance of a commercial proving of whatever processes may be employed to extract the potash, or, on the other hand, in the absence of estimates on the quantity of covered leucite-rich rock, it is nevertheless interesting to note that with a practicable reduction process, the Leucite Hills contain sufficient potash on the basis of the Survey estimate to supply American farmers, even at the present tremendous rate of increase in the use of potash, for several hundred years.

Assuming that the extraction of the potash or alumina from the leucite rocks becomes commercially successful it is regarded as fortunate that the deposits of the Leucite Hills lend themselves readily to transportation. The Union Pacific Railroad crosses the area, and feeders from some of the leucite mesas and buttes, with easy grades, could be readily connected with the main line. Gravity could be utilized in part in running the loaded cars from the mines to the main Union Pacific line. The proximity of the deposits to the Rock

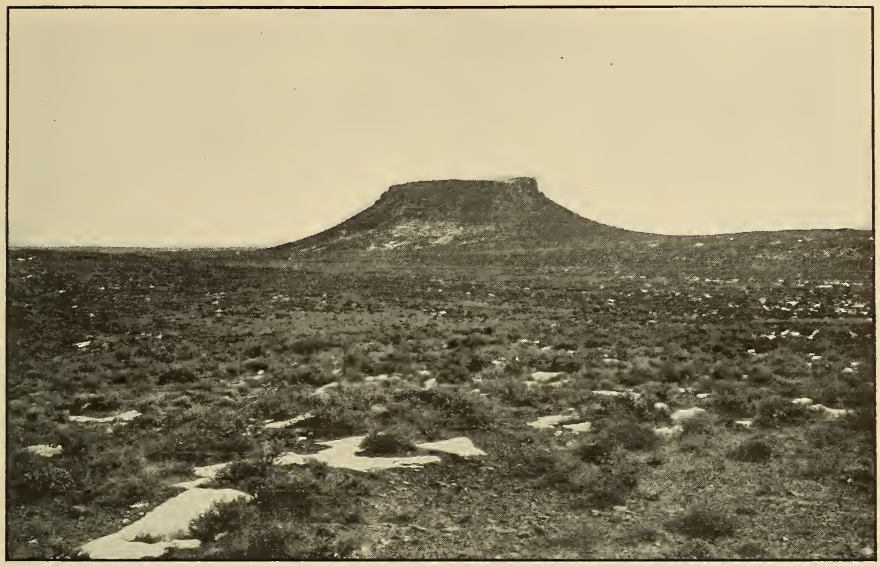


BOAR'S TUSK, LEUCITE HILLS, WYOMING

Springs coal fields is also an important item.

So far as known, no final patent has been granted by the United States to any of the lands in which the lava occurs, except the odd sections within a distance of 20 miles of the Union Pacific main line, which were included in the company's original grants. The total number of forty-acre tracts in the Rock Springs field in which exposures of potash-bearing rock are found, according to the Geological Survey, number 290, containing approximately 11,600 acres. Of this amount, 154 tracts, or 6,160 acres, still belong to the Government, and 136 tracts, or 5,440 acres, belong to the Union Pacific Railroad, unless that company has disposed of its title since the receipt of final patent from the government.

PILOT BUTTE, LEUCITE HILLS, WYOMING

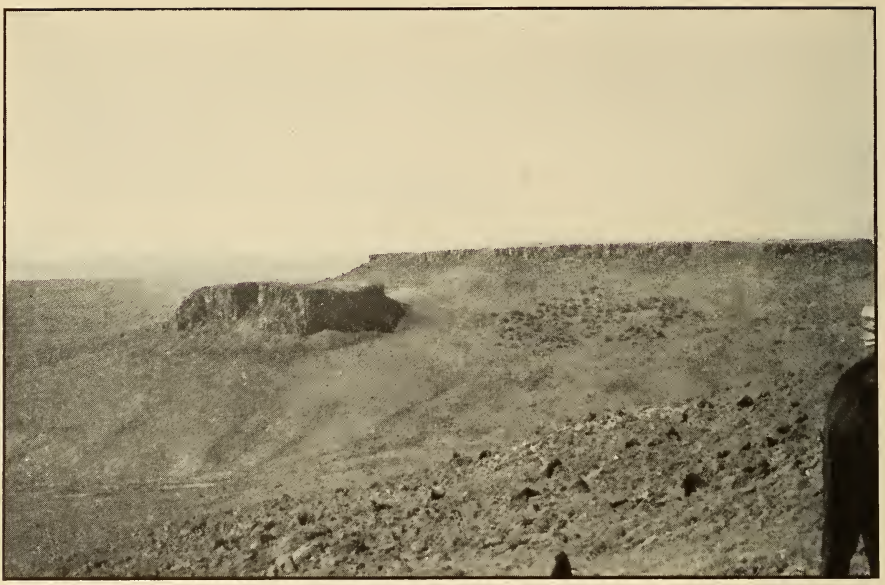


BLACK ROCK, LEUCITE HILLS, WYOMING

According to the records of the General Land Office only one entry—a homestead—is on file within the lava areas of the Leucite Hills. It is noted by the Survey that no provision exists in the present law which permits the withdrawal or reservation of land from mineral entry on account of potash, or, in fact, any minerals other than coal, oil, or phosphate. The government lands are therefore presumably open to entry. The Survey report gives a table showing the location of the areas of the leucite-bearing rocks, by section, township, and range, and indicates what tracts are still part of the public domain.

In connection with the published statement of the American Potash Company that it "owns the one workable deposit of the substance so far

A DISTANT VIEW OF BLACK ROCK



NORTH TABLE MOUNTAIN, LEUCITE HILLS

discovered on the Continent," the Geological Survey has this to say: "It is reported that the Union Pacific Railroad Company has agreed to lease, under certain conditions and for certain royalties, the right, beginning September 1, 1912, to dig rock for potash and its by-products" from certain mentioned lands lying on Zirkel Mesa, aggregating 2,080 acres. The remainder of Zirkel Mesa as well as all the rest of the leucite area, so far as the records of the General Land Office show, is public domain, except that as noted, one 160-acre homestead entry has been filed. Moreover, while Zirkel Mesa is the largest of the Leucite Hills, containing over one billion tons of "rock in sight," even this mesa as

IDDINGS BUTTE, AND DIKE AT NORTH TABLE BUTTE, LEUCITE HILLS

a whole by no means constitutes a monopoly of the potash-bearing rock. since the Survey report describes nineteen other buttes and mesas with an estimated content of over 900,000,000 tons.

In a word, the value of the leucite area would appear to depend upon the demonstration of the commercial practicability of an extraction process. Any process which will cheaply reduce this refactory lava to potash salt is of course a remarkable discovery. It may be noted in this connection that eighty-odd patents have been granted by the United States Patent Office for the extraction of potash from rocks.

TEMPERATURE OF GAS-ENGINE CYLINDERS

ITS EFFECT ON THE POWER FACTOR AND UPON HEAT EFFICIENCY

By John Batey

THE cooling of gas-engine cylinders has received experimental attention from many, and generally the deduction is that, as cylinder temperatures increase, the power decreases; but the heat efficiency increases until 212 degrees Fahr. is reached, when the limit point appears to be touched.

Practical men and users of gas engines do not appear to appreciate the labours of scientists, and pay less attention to the demonstrations that usually accompany lectures given by eminent physicists. Practical men wish to get a real grip on the means they must employ to get the greatest power from the smallest engine, costing the least money.

To them actual efficiency means little, because they measure efficiency from what they obtain as a final result, and care little for the in-between results, of which the percentage value of the heat referred to the total possible heat derived from a given value of fuel is part of the general result.

That power does decline as the walls of a cylinder increase in temperature is fairly well known, though few appear to know that actual heat efficiency increases as the temperature.

Experimental tests have proved the assertions; but it can be shown by reference to a very common law, and the latter reason is what the practical man wishes most.

However cooling is effected, whether by water or air, the atmosphere is the eventual bourne of all lost heat.

No gas-engine cylinder can be kept at atmospheric temperature during its working periods; therefore, no cylinder can be filled with mixture at atmospheric temperature, neither can the volume be of the general weight of common air.

Very little true knowledge appears to exist in regard to alterations of temperature and weight of substance which occur in a gas-engine cylinder, due to conditional temperatures during the period of working.

Before such different effects can be measured the actual conditions pertaining to working practice must be understood.

Take any cylinder of an engine designed for a given theoretical ratio of compression and obtain a trial result, when it will be found that an average actual pressure exists which is different from the calculated average pressure derived from the theoretical rates of compression effect.

Such average actual pressure is necessarily influenced by the heat value of the substance, and this heat value, if referred to weight for a given volume, is obviously less for a less weight of substance if retained in an equal volume, due to an increased temperature, and with a less total heat value the power factor must be less.

The question of power is the difference in temperature between that of the entering substance taken as a gas and the exhaust gases at the moment of discharge.

Supposing the exhaust gas retained as a residual gas in the combustion or clearance space is 900 degrees Fahr. whilst the temperature of the mixture charge is 80 degrees Fahr. The difference is 820 degrees Fahr., and the value of the work done is referable to the difference in temperature, and the power effect is

high when compared with the entering temperature of 200 degrees Fahr. The power result is necessarily as a proportion; but the efficiency of the latter is higher than that of the former, because the waste gas held in the cylinder in the exhaust stroke has been heated through a greater number of degrees, and the efficiency is less for the lower inlet temperature than for the higher.

But the higher the temperature of the charge gas, the less the weight, and a proportionate less quantity of total heat; therefore, the efficiency is obtained from a less weight of gas of a less total heat. This distinction is important, and is too often lost sight of.

At the moment when the exhaust valve closes, the residual gas, boxed up in the end of the cylinder, may be, say, at 17 pounds per square inch pressure, or 2 pounds above atmosphere.

This gas must be expanded down to less than atmospheric pressure before the new charge under atmospheric pressure can enter, and the increased volume must be allowed for by allowing an extra cylinder displacement.

Though the incoming charge may be 62 degrees Fahr. and the residual gas 900 degrees Fahr., their admixture cannot change the actual volume, though it can, and does, influence the weight quantity of the charge.

Suppose the temperature of the substance at the end of the suction stroke is 140 degrees Fahr.; then the weights must be in proportion to the absolute temperatures, and a still further piston displacement must be allowed for if the original theoretical ratio is to be obtained in the result.

Further, when the suction stroke is completed the pressure is less than atmospheric; so another allowance of extra displacement must be provided for.

Generally speaking, where the results are referred to a compression ratio of 4 to 1 (theoretical) to meet the case, the engine must be designed for a 5 to 1 ratio (theoretical).

This is the starting point for future deductions. Assuming an engine is designed to meet the theoretical conditions, the power result still rests upon cylinder temperature.

With such an engine there is no further need to trouble about what takes place inside of the cylinder, because it will be enough to consider the outside temperature of the cylinder walls alone, or, what is the same thing, the varying temperature of the cooling water as it leaves the outlet.

The assertion is reasonable and it is easily proved. Close calculation is not needed, but a rough estimate will aid knowledge.

Suppose it is possible to keep the cylinder walls down to 62 degrees Fahr. or the cooling water enters and leaves at that temperature; then the maximum power would be obtained from the substance.

Such a condition is not possible, because it n easily be three times 62 degrees Fahr., or 186 degrees Fahr., equal to a difference of 124 degrees Fahrenheit.

Let the specific heat of the gas equal 0.236, or 0.236 unit is required to raise, say, 1 pound of gas through 1 degree Fahr., and if the weight is only one-sixth of a pound then 0.0392 unit is needed to produce a similar result, and $124 \times 0.0392 = 4.86$ units of heat are lost to the power effect.

Suppose the leaving temperature of the water equal to 212 degrees Fahr., the difference is 150 degrees Fahr., and $150 \times 0.0392 = 5.88$ units are lost for every one-sixth of a pound of gas; therefore, the power result must be less, and the higher the temperature of the cylinder walls, the less is the power result.

Some time ago Professor Hele-Shaw gave the results of actual experiment to the Institution of Mechanical Engineers, and they are as follows:

PROFESSOR HELE-SHAW'S RESULTS

Temperature F°.

No. Test.	Entry.	Exit.	B. H. P.	Rev.
1	66.2	77	4.775	1,086
2	64.4	131	4.47	1,084
3	64.4	212	3.97	903
4	212.	212	4.07	925
5	253.4	253.4	3.94	906

In 1, 2 and 3 the water was allowed to flow through, but in No. 3 only a small quantity was allowed to flow to compensate for the water evaporated.

Nos. 4 and 5 were boiling-off experiments, and in No. 5 glycerine was used.

The loss of power between No. 1 and 2 = 0305 H. P. = 10,065 foot-pounds, and the difference of temperature equals 64.8 degrees Fahr., or 155 foot-pounds per degree Fahrenheit.

Taking the specific heat as 0.236 and calculating that 183 foot-pounds of work must be performed to attain 1 degree Fahr., and as 183 : 155 :: 1 : 0.84 pound—the assumed weight of gas utilized during the operation—the result shows that 155 foot-pounds are lost for each 1 degree Fahr. rise of temperature of the cylinder walls.

Between Nos. 1 and 3 the loss is 0.805 H. P. = 26,676 foot-pounds, and the differences in temperature equal 136.8 degrees Fahr.

26,676 ÷ 136.8 = 195 foot-pounds per degrees; therefore, the loss increases faster than the rise of temperature.

The economy required is derived from a plant costing the least money, giving the greatest power on the lowest consumption.

Low consumption means high efficiency; but if the efficiency rises 5 per cent., whilst the power declines, say, 17 per cent., then such economy is not what the practical man requires.

Examining No. 4 test, where water of 212 degrees Fahr. was caused to flow in, then evaporated under the same temperature, it is seen that the brake-horse-power is increased beyond that of No. 3. The reason is plain, being due to the increased efficiency of a hot cylinder; but such a condition cannot be recommended as a safe method.

During the ensuing discussion on the paper Herr R. Diesel said that, after a great number of experiments, the main fact told by Professor Hele-Shaw was that the power of internal-combustion engines decreased very rapidly with increase of temperature.

Mr. Dugald Clerk gave the result of many experiments, in which he found that, going from 60 degrees Fahr. to the boiling point, the efficiency increased with a slight decrease in power, showing an increase in actual economy.

Mr. Clerk's experiments were carried out with one of his own gas engines, whereas Professor Hele-Shaw's were made with a small motor vehicle.

Thus, it is evident that the slow-running engine must give a higher conditional efficiency than the small, high-speed motor engine.

The reason is not far to seek, because the gas-engine cylinder, by its size, holds a greater quantity of hot gas exposed to a relatively smaller surface than the small-capacity motor cylinder.

This is quite in accordance with common knowledge, because the area increases as the square of the diameter, whereas the surface increases directly as the diameter; and it is also well known that the temperature of a small body of gas for one mixture condition is only equal to that of a much larger body. Therefore, the relatively smaller dispersing surface of the gas-engine cylinder is entirely in favour of efficiency.

As a practical determination for the heat of a gas-engine cylinder, it should never be allowed to exceed the temperature given by the makers; whilst a motor cylinder should be kept as cool as possible consistent with the quantity of water the car can carry.

HIGH-SPEED TURBINE PUMPS

By J. W. Rogers

(Concluded from the March issue)

IT has already been stated that when a centrifugal pump is working against a higher lift than that for which it was designed, it may either fail to discharge or will deliver much less than its normal quantity; but it may be made to operate at something near its normal capacity by increasing the speed, and a great advantage of the centrifugal pump is that the quantity may be regulated over a considerable range by throttling the discharge without causing a serious decline in the efficiency.

On the other hand, when a pump is working against a lower head than the normal, it will deliver more than its rated quantity; but if the excess of pressure is not very great the quantity may be controlled by partly closing the discharge valve, or, if possible, by slightly decreasing the speed.

As stated above, it is the practice to connect up a centrifugal pump for pressure work by introducing several stages when it is required to work against very high lifts; and, on the other hand, the impellers may be arranged in parallel for pumping large quantities of water against small heads. In this case, the discharge is divided amongst the impellers, each of which delivers only a fraction of the total quantity of water, and an example of this type of pump is shown in Fig. 6, representing a 30-inch Worthington twin centrifugal, 400 brake-horse-power pump and motor, which is capable of dealing with large quantities of water and specially designed for graving-dock service.

It is a well-known fact that to raise water economically with a centrifugal pump the diameter of the impeller must bear a definite relation to the speed, height of lift and the quantity to be discharged, and when small quantities are dealt with the diameter of the impellers must be small, which limits the circumferential speed; consequently, the number of stages necessary for high lifts is greater than that required to deal with large quantities of water at low lifts. A large number of stages generally means a decrease in efficiency; but as impellers of large diameter may be employed in pumps dealing with large quantities, the number of stages required is small, and for this reason it is possible to obtain fairly high efficiencies with this type of pump. As a general rule, it is impossible to obtain very high efficiencies when the quantity is small in comparison with the height of lift. The illustration in Fig. 7 gives a general view of the latest type of Worthington high-lift centrifugal pump, in which the intermediate stages are clearly defined. The pump casing is composed of separate sections of cast iron or steel (depending upon the pressure required), which are accurately machined before being bolted together; and as all the sections are interchangeable, this method of construction enables the pump to be quickly dismantled.

The impellers are special hard phosphor-bronze, carefully machined, polished, and mounted on a nickel-steel shaft. Each impeller delivers into a single diffusion passage of special design formed in the intermediate casings and delivery cover, which serves to convert the velocity of the liquid, leaving the impeller

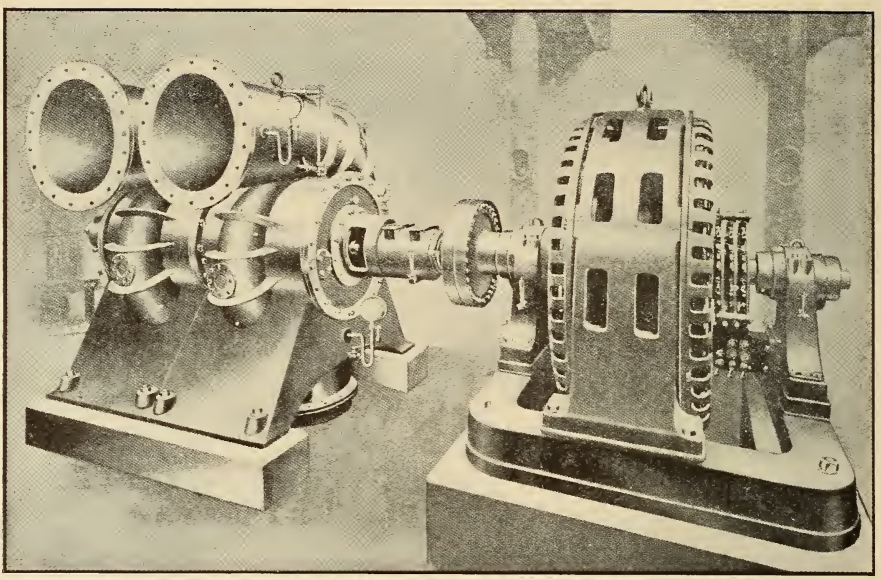


FIG. 6.—WORTHINGTON 30-INCH TWIN CENTRIFUGAL PUMP AND 400-B. H. P. MOTOR INSTALLED AT TEES DOCK, MIDDLESBROUGH

into the required static pressure; and the makers claim for this arrangement an increased efficiency over the method employing a system of guide vanes, on account of the liability of the latter to wear when the water contains sand and foreign matter. Any tendency to produce axial thrust in this pump is compensated by an automatic balancing device, and side thrust between the motor and pump is prevented by using a flexible coupling between them. The question of balancing the longitudinal thrust, due to the change in direction of the water in the impeller when the inlet is on one side only, is a point of great importance in the design of centrifugal pumps, and especially with those of the multi-stage type.

The simplest method of balancing a multi-stage pump is that due to Mather & Platt and Sulzer Bros.,

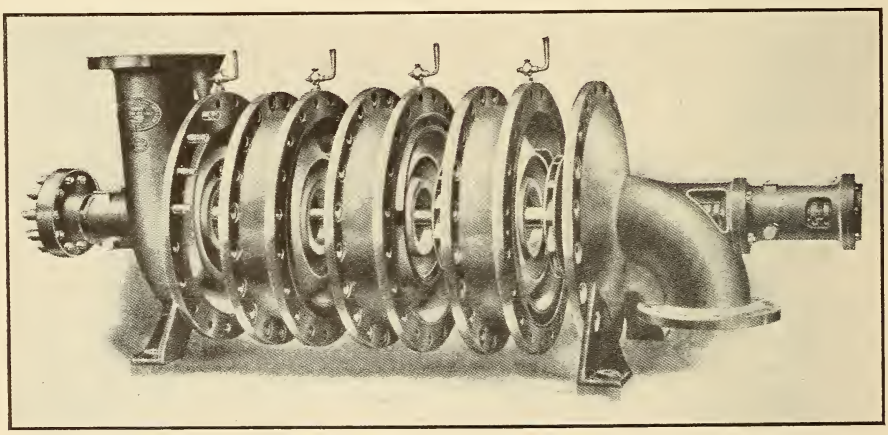


FIG. 7.—GENERAL VIEW OF WORTHINGTON NEW STYLE HIGH-LIFT CENTRIFUGAL PUMP, SHOWING INTERMEDIATE STAGES

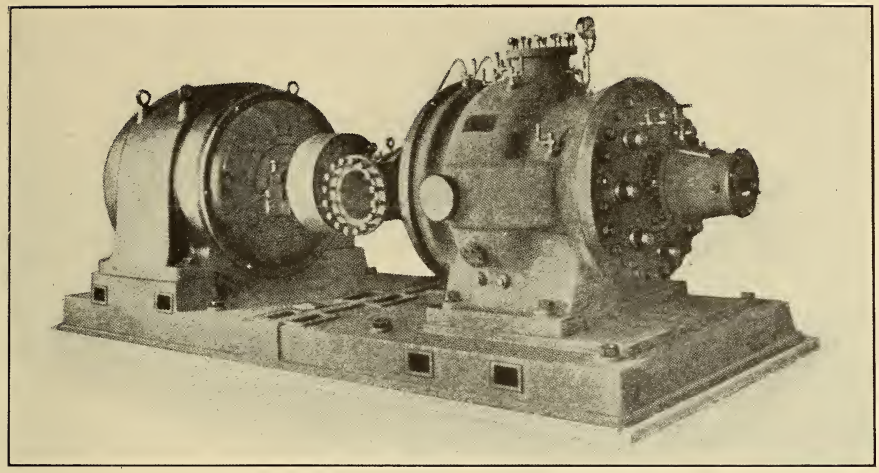


FIG. 8.—SIX-STAGE HIGH-PRESSURE CENTRIFUGAL PUMP

who employ a very effective hydraulic balancing arrangement, which consists in mounting the impellers in pairs back to back, and as a result of this the residual thrust is extremely small.. The illustration in Fig. 8 represents a Weise & Monski six-stage turbine pump driven by an 850 brake-horse-power motor at 450 revolutions per minute and capable of discharging 7,320 gallons per minute against a head of 1,560 feet. In Fig. 8a is shown the pattern of the guide ring used in pumps made by this firm, and the curves in Fig. 9 show the operating characteristics of one of their 5-stage turbine sinking pumps when running at a constant speed. The illustration in Fig. 10 represents a 6-stage Sulzer high-lift turbine pump, and the characteristic curves in Fig. 11 show the performance of a 5-stage Sulzer pump when running at constant speed.

The "Victoria" turbine pump, made by Willans & Robinson, is illustrated in Figs. 12 and 12a. It is fitted with a special device for balancing the end thrust of the impellers, at the same time adjusting itself automatically to changes of head and output while the pump is running. Another feature of the Victoria pump is the absence of a stuffing box, as only a low pressure exists in the end chamber behind the last diaphragm. The characteristic curves in Fig. 13 represent the results of a recent test on a Victoria pump capable of discharging 2,900 gallons per minute against a head of 315 feet. The power required for this duty was 325 brake-horse-power, and the efficiency was 86 per cent., as compared with the guaranteed efficiency of 78 per cent.

REGULATION

The most convenient system of regulation for centrifugal pumps is by the throttle or sluice valve in the delivery pipe; but this is a very inefficient method, as when the valve is closed the pump still absorbs about

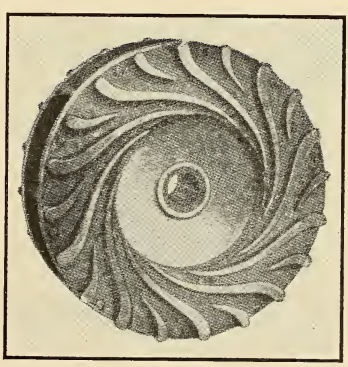


FIG. 8A.—GUIDE RING OF A HIGH-DUTY CENTRIFUGAL PUMP

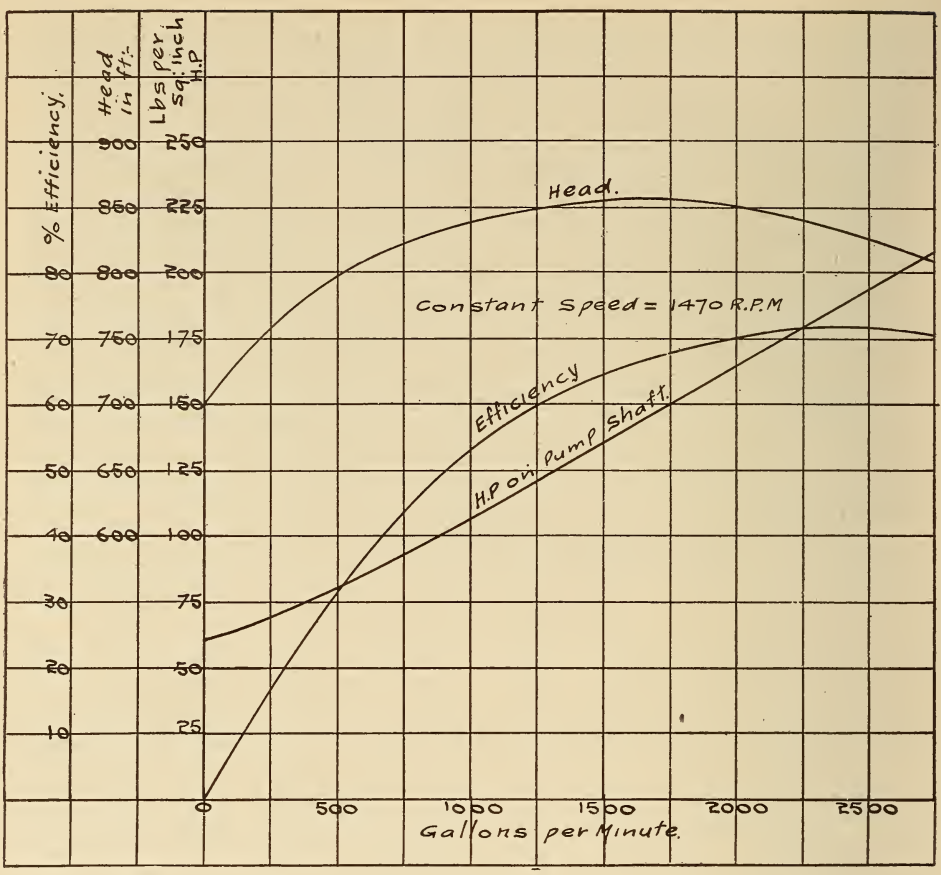


FIG. 9.—CURVES SHOWING OPERATING WORK OF THE WEISE & MONSKI FIVE-STAGE TURBINE SINKING PUMP WHEN RUNNING AT A CONSTANT SPEED

40 per cent. of its full power. This method of regulation is generally used in practice when the variation in working conditions is only temporary; on the other hand, when such variations last for long periods, in order to secure high efficiencies the choice lies between the regulation of volume or lift. In the case of a single-stage pump the regulation of the lift can be obtained only by varying the speed, since the head depends upon the speed; but this regulation is only possible within certain limits, as it depends upon the speed control of the motors.

When pumps are driven by alternating-current motors the speed is generally a constant factor, as the cost of suitable regulating apparatus would be prohibitive. In the case of direct-current motors, however, speed regulation is easily obtained.

As regards the regulation of the head in multi-stage pumps designed for a maximum lift, this may be easily effected by bye-passing one or more stages, according to the actual head to be overcome, the remaining stages working at the same efficiency as that obtained when the pump is working under normal conditions, and the following example of the application of this method of regulation may prove of interest:

A certain 6-stage turbine pump suitable for a normal manometric head of 200 feet was put to work

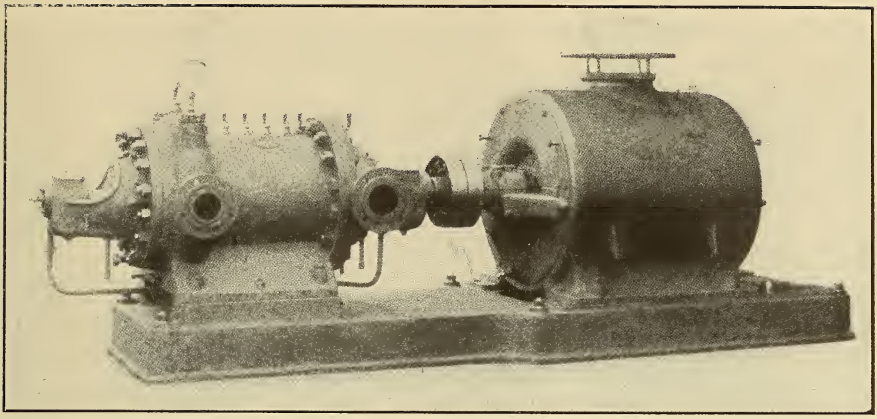


FIG. 10.—SIX-STAGE SULZER HIGH-LIFT CENTRIFUGAL PUMP, COUPLED DIRECT TO ELECTRIC MOTOR

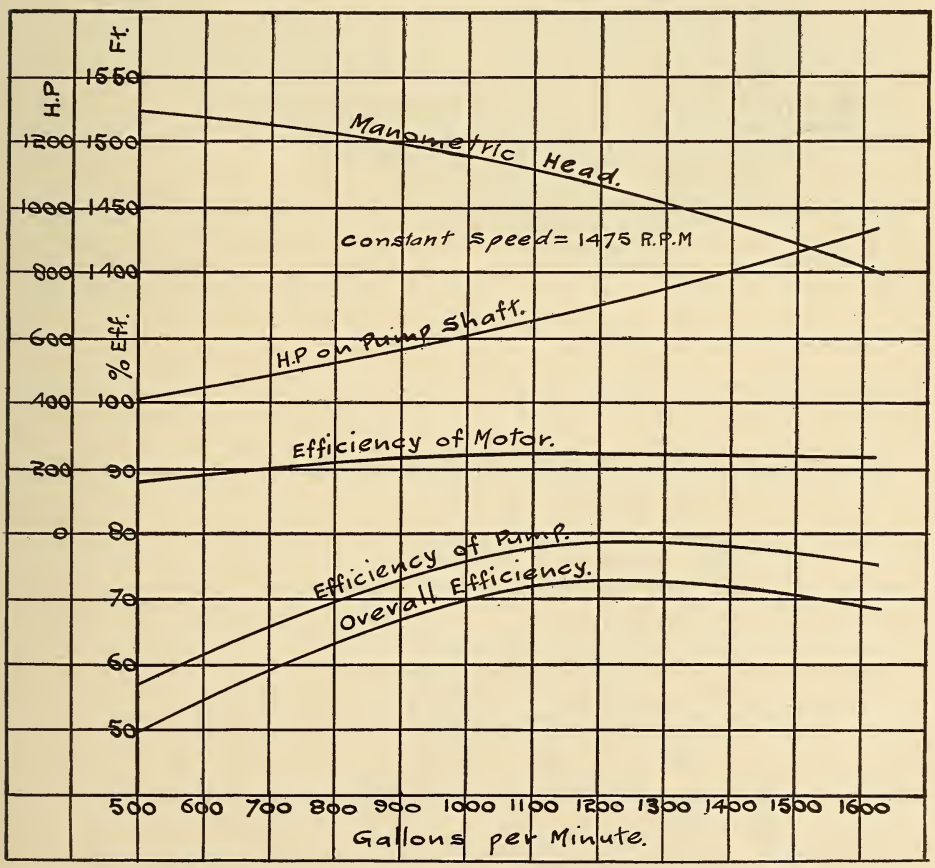


FIG. 11.—CURVES ILLUSTRATING THE WORK OF A FIVE-STAGE SULZER PUMP WHEN RUNNING AT A CONSTANT SPEED

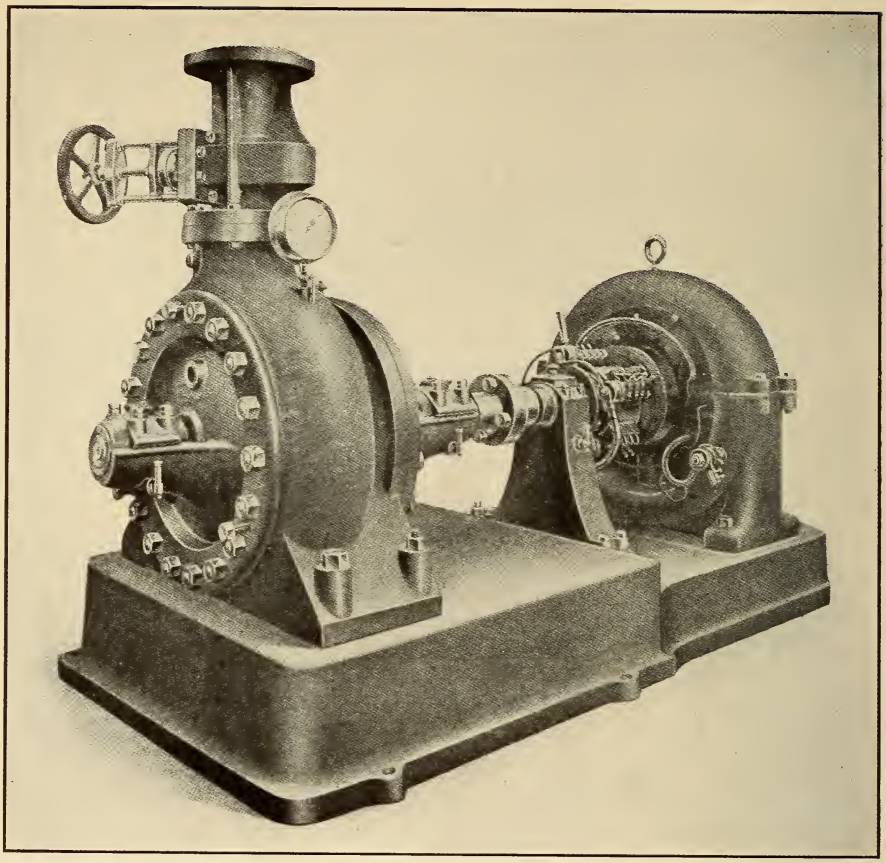


FIG. 12.—VICTORIA HIGH-LIFT PUMP COUPLED TO ONE MOTOR

against a head of 145 feet, and it was, therefore, necessary to throttle 55 feet of head to prevent the pump from being dangerously overloaded. If this was done by partially closing the discharge valve it would mean a considerable waste of power, but this difficulty was overcome by removing two impellers and two guide wheels and substituting distance pieces specially provided for this purpose.

The suction impeller was not removed, but the fifth and sixth impellers were taken out—that is, those nearest the delivery side of the pump. The pump was able to deliver its normal quantity of water against the existing head of 145 feet with the remaining four impellers, and the power consumption was decreased to about two-thirds of that required when the pump was working at its full capacity.

The regulation of the volume is not possible with multi-stage pumps, but may be effected in single-stage pumps by varying the admission. The question of regulation or adjustment to varying heads of centrifugal pumps is of considerable importance in mining work, and has received the attention of the Rees Roturbo Company, who, after prolonged and exhaustive tests, have succeeded in designing a self-regulating pump, by means of which it is possible to obtain a high efficiency over long periods, and the principles and construction of the Roturbo pump may be described as follows:

The distinguishing feature of this

pump is in the construction of its impeller, which is illustrated in Fig. 14. It is designed in the form of a large-capacity drum or pressure chamber, the object being to obtain a constant pressure inside the drum equivalent to the height of lift. After the water has been sucked up into the eye of this drum it becomes practically stationary relatively to the drum itself, thus eliminating friction losses and generating a pressure by centrifugal force. In the rim of the drum are a series of turbine blades, which are backward curved, and form short passages which impart to the water a resultant discharge speed amounting to half the peripheral velocity of the drum when the pump is working at its normal duty. As the full pressure is generated inside the revolving drum, it is possible to throw the water back tangentially without sacrificing efficiency. The diminished velocity of the water in the fixed casing, due to the rearward ejection from the drum, coupled with the fact that the fixed guide rings are situated some distance from the rim of the drum, ensures a high efficiency, and avoids the necessity for highly polished surfaces and renewable tips and blades.

The drum of a Roturbo pump is really a combination of a centrifugal pump and a turbine in series with a large-capacity pressure chamber between the two portions. The resultant effect of this combination is to render an overload, due to reduction in the head, impossible. This is caused by the action of the turbine blades of the impeller, which extract the energy of the increased speed of the water flowing through the drum, thus preventing overloads on the pump.

The illustration in Fig. 15 represents a cross-sectional view of a high-lift multi-stage Roturbo pump, which is built up of a number of sections at right angles to the shaft,

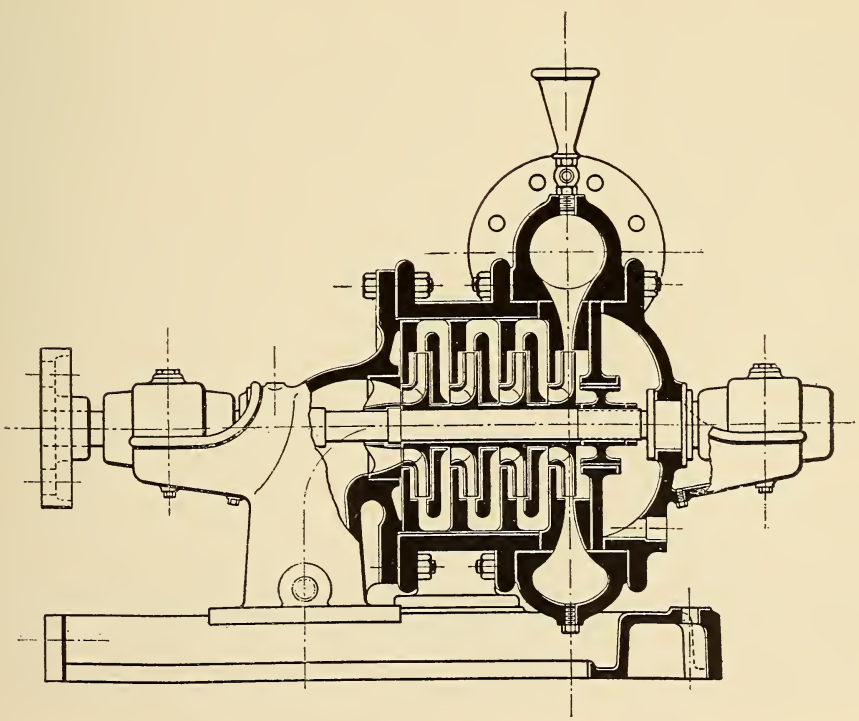


FIG. 12A.—DIAGRAM VIEW OF THE VICTORIA TURBINE PUMP

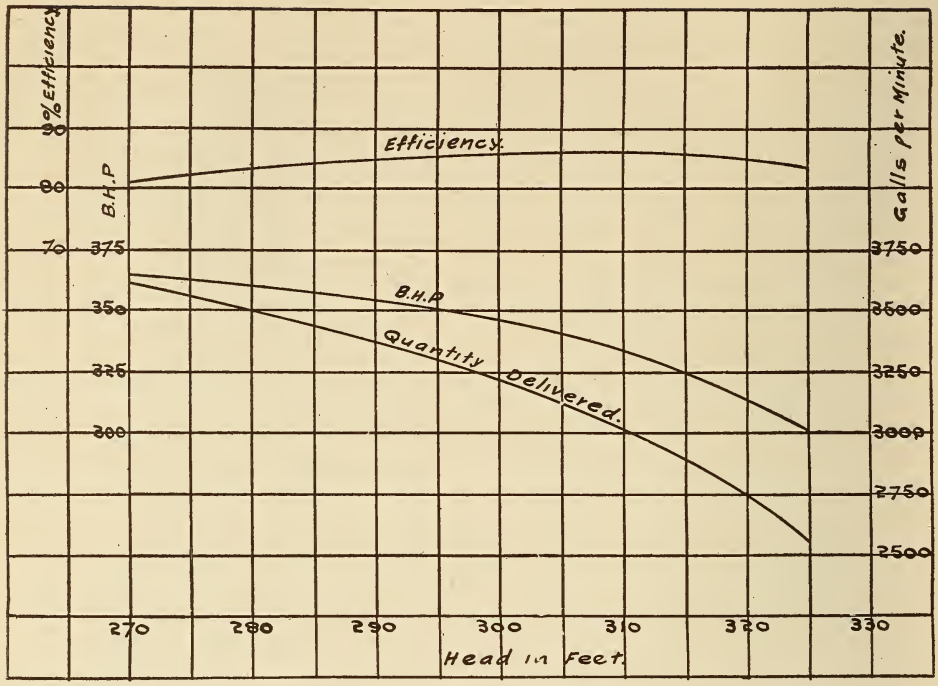


FIG. 13.—CURVES REPRESENTING THE RESULTS OF A TEST ON A VICTORIA PUMP DISCHARGING 2,900 GALLONS PER MINUTE AGAINST A HEAD OF 315 FEET

a general view of a pumping set capable of delivering 50,000 gallons per hour against a head of 570 feet being shown in Fig. 16.

The exact characteristics of the Roturbo pump are illustrated in Fig. 17, which shows the variation of head, volume, power and efficiency with a decrease of motor speed, also giving the self-regulation at each speed.

A reference to the curves in Fig. 18 shows that when a Roturbo pump is driven at constant speed the head against which the pump is working may be reduced from the normal lift down to zero without any increase in the power required to drive it beyond the brake-horse-power necessary for its normal duty, notwithstanding the fact that at zero head the volume increases to about 200 per cent. above its normal value.

It will be seen that the power curve on low head and increased volume has a downward tendency, which is brought about without any throttling effect or inherent loss of efficiency.

This feature of self-regulation ren-

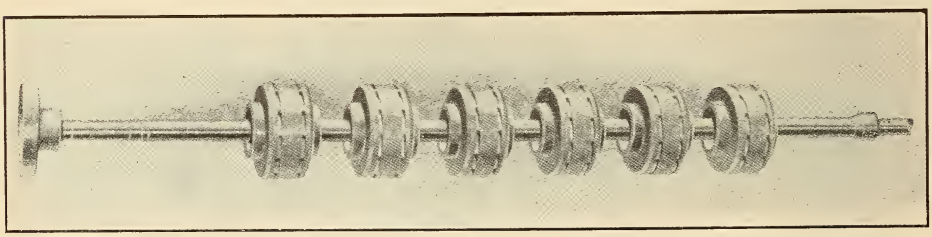


FIG. 14.—REVOLVING PRESSURE DRUMS ON SHAFT

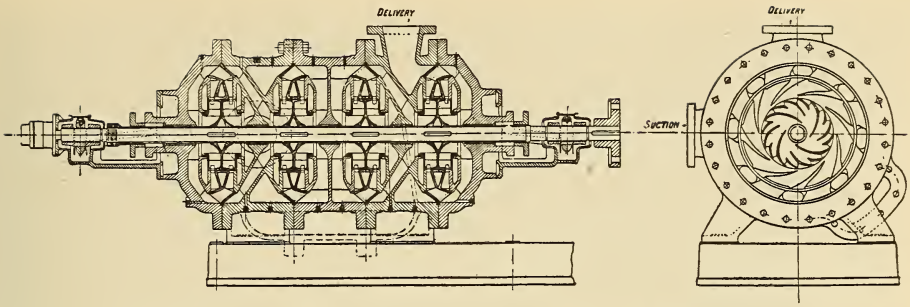


FIG. 15.—CROSS SECTIONAL VIEW OF A HIGH-LIFT MULTI-STAGE ROTURBO PUMP

ders it unnecessary to allow a certain margin of power at overload capacity with Roturbo pumps, as it is impossible to overload them by any reduction of head, provided that the speed is held constant.

An important development in the design of high-speed centrifugals was the introduction by Sulzer Bros. of the vertical turbine pump about twelve years ago. Such a pump is generally coupled to an alternating-current motor, the combination being bolted to a channel iron frame, as shown in Fig. 19, which represents a Sulzer sinking pump designed for high lifts, a double sinking pump by Weise & Monski being illustrated in Fig. 20.

The weight of the rotating part of the motor is taken up on an adjustable thrust bearing, and the impeller shaft is also supported by a thrust bearing, which is provided with a

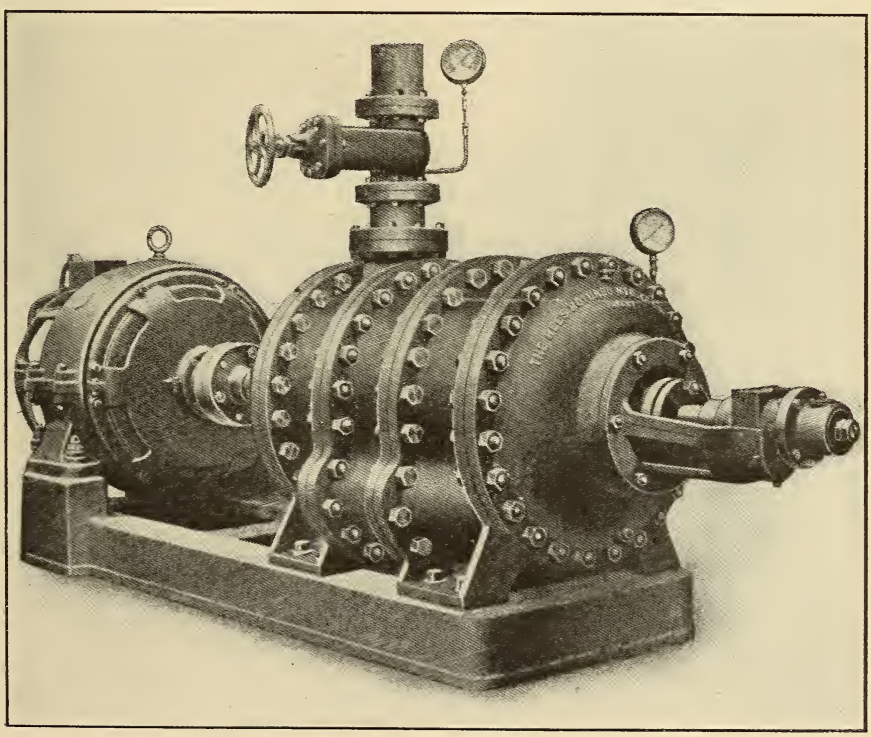


FIG. 16.—REES ROTURBO HIGH-LIFT COLLIERY PUMP

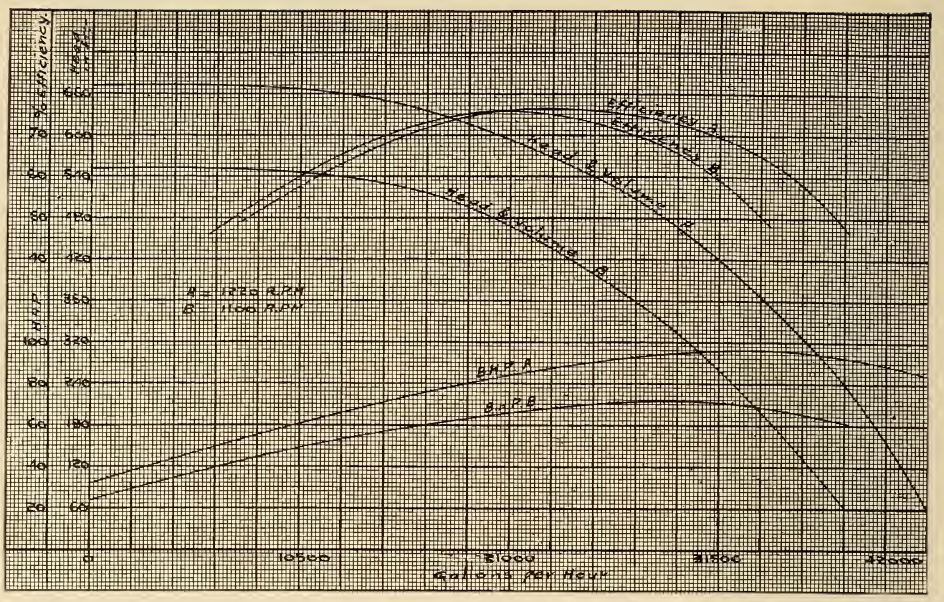


FIG. 17.—VARIATION CHARACTERISTICS OF THE ROTURBO PUMP

cooling chamber. The discharge is controlled by a delivery valve placed directly above the pump, and above this is a check valve, which supports the weight of water contained in the delivery pipe when the pump is stopped. It will be seen from the illustration that the whole arrange-

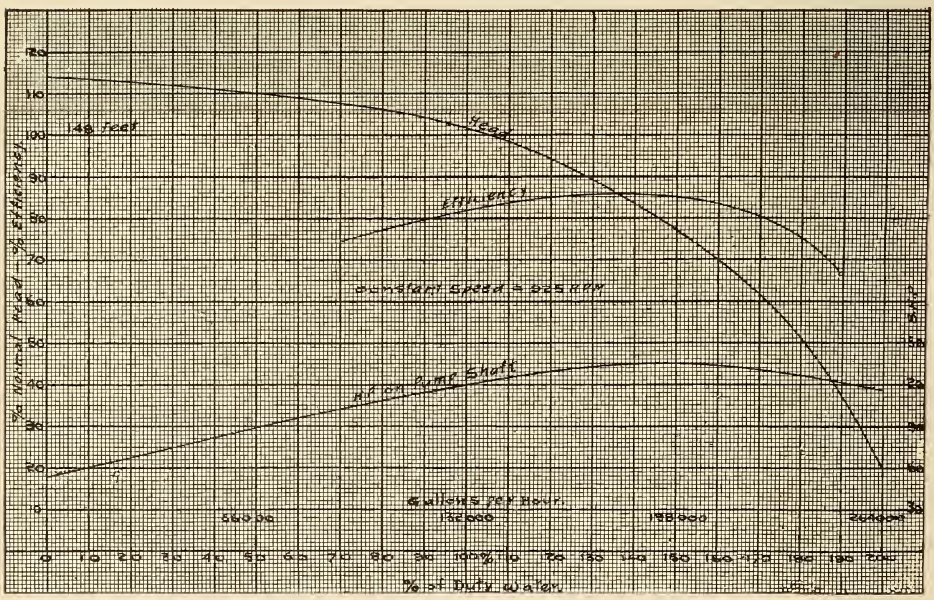


FIG. 18.—DIAGRAMS OF ROTURBO PUMP OPERATED AT CONSTANT SPEED

ment is ideal for shaft-sinking operations, as the pump occupies little space in the shaft, and, although self-contained, is quite accessible.

As is well known, sinking pumps are designed to deliver the required quantity of water against an indefinite head; consequently, motors driving turbine pumps working at constant speed during the unwatering of old mines or for sinking purposes are liable to be severely overloaded during the early stages of pumping. To overcome this difficulty several important improvements have been made in the latest Worthington type of vertical pump which enable it to work at zero head with the discharge valve full open without exceeding 25 per cent. overload.

The Roturbo pattern of vertical pump is illustrated in Fig. 21, which is well adapted for sinking purposes, due to its self-regulating qualities and high efficiency over a wide variation in the total lift.

The successful working of centrifugal pumps is generally secured by attention to a few simple precautions, which should be taken with all types of pumps, and, although a modern pump will work satisfactorily with a suction lift up to 26 feet, it should be reduced to a minimum, as a short lift enables the suction piping to be maintained practically air-tight without much difficulty.

The disadvantage of a high-suction lift is that low-lift pumps are liable to lose their water after being charged; also, the admission of air into a high-lift pump will interrupt the continuity of the flow of water, which will result in a decrease in the efficiency and in some cases cause vibration in the pump.

A turbine pump will lose its vacuum under the following conditions:

Firstly, when a leak occurs in the suction line it causes infiltration of air to accumulate at a point, such as a bend, thereby establishing an air pocket and destroying the vacuum.

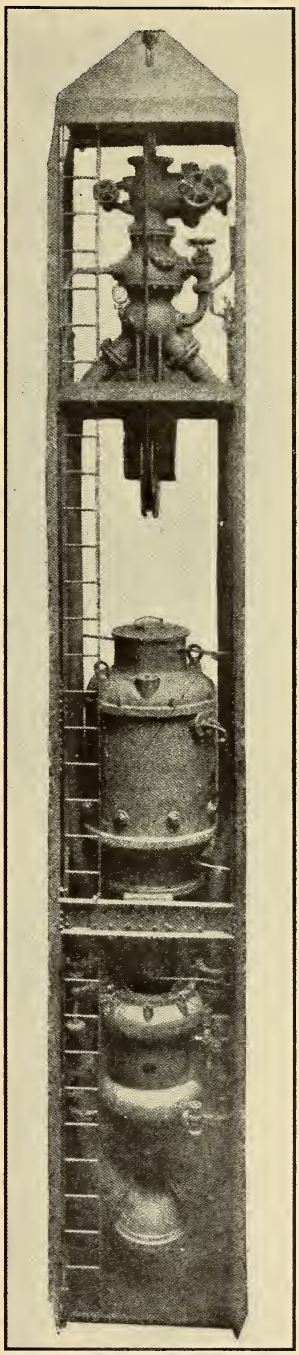


FIG. 19.—SULZER SINKING PUMP DESIGNED FOR HIGH LIFTS

Secondly, when the height of lift exceeds the elevating power of the pump a churning of the water in the pump takes place, and the resulting friction will cause a rise in temperature.

The vacuum obtained under these conditions is then determined by the steam tension corresponding to the water temperature.

The theoretical vacuum created by a pump without taking the air pressure into account is given in the following table:

Temp. of of Water.	Theoretical Vacuum in Inches, 30-in. Barom.	Water Lift.
80	29	33.2
102	28	32.0
126	26	29.7
150	22.5	25.7

TESTING OF CENTRIFUGAL PUMPS

In all modern shops which have been specially laid out for the manufacture of these pumps the testing department occupies a position of great importance, as it is necessary to carry out a series of tests on each individual pump to ensure that the plant turned out attains the specified efficiency, and also to obtain a knowledge of the operating characteristics of a pump under working conditions.

As with all high-speed machinery, it is necessary to adjust the rotating parts of centrifugal pumps for static balance, and also for running balance at various speeds when assembled, and the balancing devices used for this purpose by Weise & Monski are shown in Figs. 22 and 23.

They are mounted on cement foundations and separated from the rest of the building to prevent vibrations and deflections from the horizontal plane.

To determine the efficiency of an electrically-driven centrifugal pump with any degree of accuracy it is necessary to take the following readings simultaneously:

PUMP READINGS

(1) Manometric height of lift H_1 in metres or feet, which is indicated by a pressure gauge inserted between the pump and delivery valve.

(2) Manometric height of suction or vacuum H_2 as measured on a gauge fixed in the suction branch.

(3) Head, due to friction of water in pipes H_3.

(4) Quantity pumped in litres or gallons per minute.

MOTOR READINGS

(1) Input current in amperes.

(2) Terminal voltage.

(3) Kilowatts input measured on wattmeter.

(4) Speed of shaft.

The quantity of water is generally determined by the aid of calibrated tanks, or a water-meter.

The following results of a test carried out on a Weise & Monski high-lift turbine pump driven by a three-phase motor at 1,490 revolutions per minute and capable of raising 1,200 gallons of water per minute against a static head of 1,935 feet may prove of interest:

Static height of lift $H_1 = 1{,}918.3$ feet.

Static height of suction $H_2 = 15.1$ feet.

$\therefore$ Total static height $H_1 + H_2 =$ 1,933.4 feet, and total manometric height H, including friction, $= 2{,}061$ feet.

Pressure in pounds per square inch by gauge $= 886$, and, as 1 pound represents 2.32 feet of head, this gives a total calculated head of $886 \times 2.32 = 2{,}060$ feet.

Quantity of water delivered per minute $= 1{,}252$ gallons.

Water H. P. of pump $= \dfrac{1{,}252 \times 10 \times 2061}{33{,}000} = 782$ H. P.

Amperes per phase $= 170$.

Terminal volts $= 3{,}111$.

Input in kilowatts $= 780.5$.

Input in K. V. A. $= 170 \times 173 \times 3{,}111 = 915$.

Power factor $\dfrac{780.5}{915} = .853$.

As the real efficiency of this motor was 96.7 per cent. for this particular load, then:

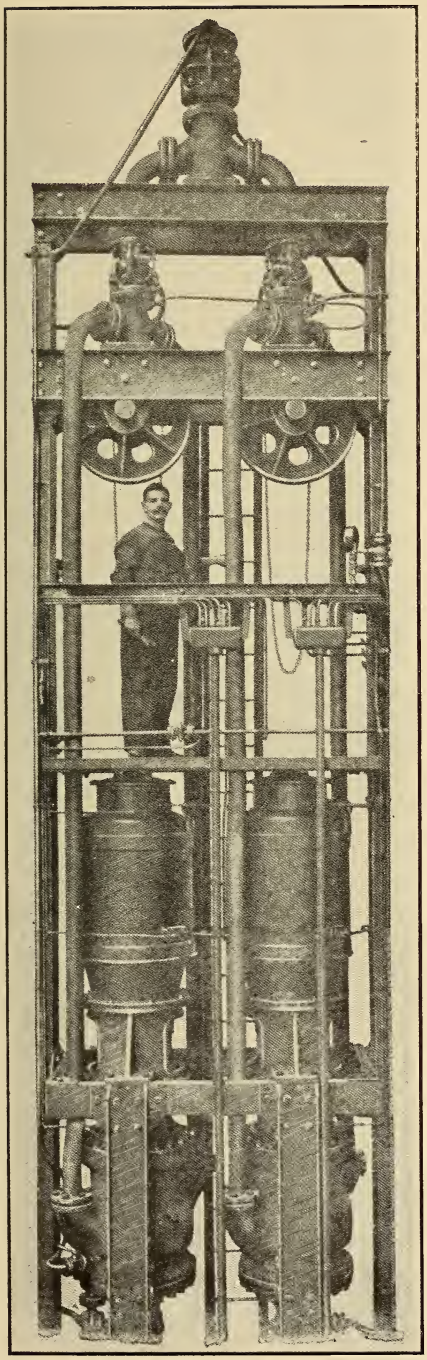


FIG. 20.—DOUBLE SINKING PUMP CONSTRUCTED BY WEISE & MONSKI

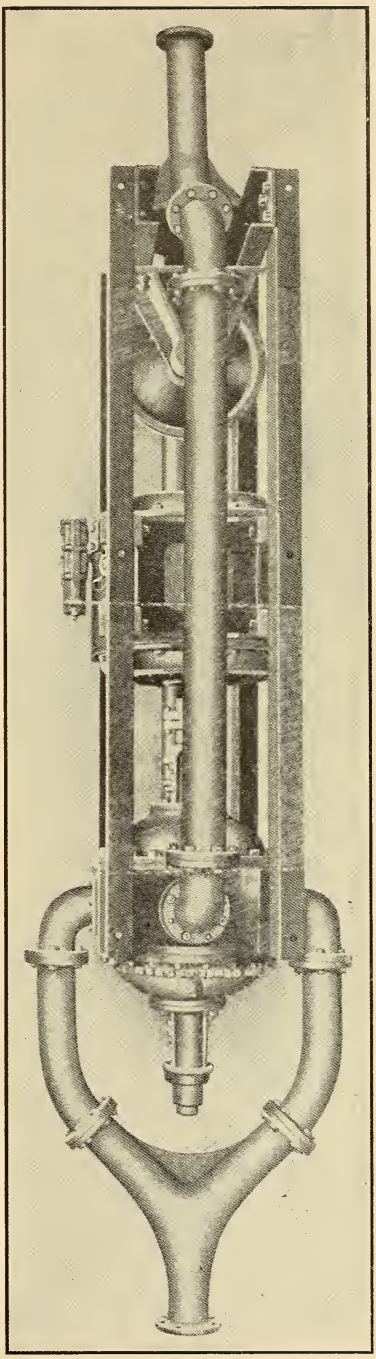


FIG. 21.—ROTURBO PATTERN OF VERTICAL PUMP USED FOR SINKING PURPOSES

Power transmitted to the pump $= \frac{780.5}{.746} \times .947 = 990.8$ H. P.

Efficiency of pump $= \frac{782}{990.8} \times 100 = 79.1$ per cent.

Combined efficiency of pump and motor $= \frac{94.7 \times 79.1}{100} = 74.9$ per cent.

In addition to the efficiency test, it is generally the custom to measure the power consumed and the maximum head developed by a pump with its delivery valve closed; a knowledge of the temperature rise of the motor after a continuous run at full load is also necessary.

In conclusion, it should be stated that, amongst the numerous applications of the turbine pump, it is now necessary to include the feeding of high-pressure boilers and hydraulic installations, both of which are beginning to constitute a promising field for the further development of this type of pump.

The writer's thanks are due to the various firms mentioned for much information and the photographs illustrating this article.

MANAGER AND SCIENTIST

By H. F. Stimpson

IN the development of commercial and industrial organizations few points have been more hotly contested than the relations between the manager and the scientist. It seems to have been taken for granted by all that one must necessarily occupy a superior and the other an inferior position, no other condition being thought to be possible. An extensive and intensive study, during five years, of the principles which govern the design and operation of organizations, following an engineering experience of twenty-five years, much of which has been in close contact with some very large enterprises, has led to a belief that the controversy as to these relations arises from:

1. A misconception of the proper functions of both the manager and the scientist.

2. A failure to recognize two distinct grades of scientists.

In order to obtain a correct general idea of these functions and the consequent relations, a correct general idea of the development of the human race is essential. The history of civilization is one continuous record of man's attempts to supplement his own powers by those derived from external sources. He first supplemented his power to warm himself by the internal combustion of food with the external combustion of fuel. He next supplemented his natural weapons of offense and defense with artificial ones. With the discovery of pottery he found means of supplementing the storage capacity of his body. The domestication of animals afforded him the first means of supplementing his muscular energy with that generated entirely outside his own body. Then came the next great step whereby man ultilized the inanimate energy of the wind or falling water to operate his machines, and, finally, the even greater one of using the inanimate and more easily controlled energy which is developed from fuel. Mechanical devices of increasing perfection have enabled him, from time to time, to utilize both his own muscular power and that derived from other sources with greater effect.

As the volume of controllable muscular and mechanical energy at his command has increased, man has found it necessary to use his own muscular energy for purposes of the control thereof, and even to supplement it for this purpose rather than to use it in the actual performance of the tasks themselves. Hence we have the large number of officials in the armies, organized both for warlike and peaceful purposes. In all of these, however, the dominating idea, so far, has been that of increasing the amount of muscular and mechanical energy controlled by one master mind. It is true that many individuals are employed in transmitting directions, in recording operations, etc.; but the central idea, permeating everything, is that the controlling individual is, or should be, able of himself to initiate every movement and make every decision relating thereto. It has always been a problem of supplementing muscle rather than of supplementing mind.

Another idea which has been held contemporaneously is that the main purpose of the enterprise was the direct benefit of the controlling indi-

vidual. The satisfaction of an existing public demand was, of course, the natural basis upon which to work. If no such unsatisfied demand was apparent, then the thing to do was to create one without much regard as to its character. The chief consideration was that the "price" which could be obtained for the commodity or service should exceed the cost of production and delivery by as great a margin as possible. Hence the supposedly great desire to reduce such cost to the producer to the lowest figure. The idea that the cost to the consumer should be minimized simply because he is the consumer, or that the origin of any enterprise is really in the idea of dividing the labour necessary to the existence of the community according to individual ability and for the public good, is a result of centuries of civilization which is only just barely beginning to exert a perceptible force upon the minds of humanity.

Out of this idea of personal gain springs the tendency to regard any so-called "non-productive labour" as an extravagance to be minimized as much as possible. Here we have the source of the desire for men who are already "competent," and can, therefore, work without making it necessary to incur expense for their supervision. It is forgotten that no crop can be reaped unless someone sows the seed; that trained men do not grow of themselves, and that the supply of such must be constantly maintained. Hence provision for such training is an essential part of any enterprise; the schools can only lay the foundation for this training.

With the increase in the volume of operations made possible by the developments in machinery and the energy by which it is actuated comes the need for supplementing the capital possessed by the controlling individual. Other individuals who possess capital, but who, for one reason or another, desire to employ it by proxy, are, therefore, enlisted in the effort as stockholders.

It is now evident that all these additional resources of energy, apparatus and capital necessitate not only that the muscular ability of the individual who controls them shall be supplemented, but also his mental ability to direct them. Control and direction are the two elements, according to Webster, of the managerial function. Heretofore in the operations of man the effort has been to increase simply that which is controlled, and, correspondingly, the power to control it. While man has long recognized his personal limitations as to muscular energy, he has been loath to publicly admit that his mental powers were unequal to the adequate performance of the directive function. He has, therefore, had recourse to various expedients, without actually realizing that they *were* expedients, in order to make good his deficiencies.

One of these has been to secure the services of those who were "masters of their trade," and who, consequently, simply needed an order—that is to say, a description of the desired result—to perform the task. If the result or the method employed to attain it were not agreeable, condemnation was sure, it being assumed that the subordinate should be able to become aware, telepathically, of his master's plans, even when no such plans existed. Another expedient is seen in the numerous varieties of the "suggestion system" scheme. This is also, as is quite apparent upon careful study, an admission of incapacity on the part of the management. If it was able to formulate complete and competent directions the possibility for suggestions on the part of those managed could not exist. It is also an example of the influence of the desire to economize by the elimination of so-called "non-productive labour." Does any sane man believe that the sum of all the petty rewards paid

for shop suggestions is anywhere near their aggregate cash value? Another hollow pretense along this line is the committee system, whereby employees, especially the overworked and under-paid foremen, are tickled with an appeal to their vanity into giving up information which the employer is either too ignorant to get for himself or too stingy to pay for.

It should not be inferred from the above, however, that all shop consultations are condemned. Far from it. Until a far greater degree of perfection in the application of the science of management has been reached than is at present the case it will be quite possible for any intelligent worker, who is close to his work all day, to see improvements—generally, however, minor ones—which are valuable. It will also be quite possible for administrative officials of all grades to perceive where corresponding improvements can be made, or, at any rate, where obstructions are manifested. The consideration of such things should be encouraged, but the matter should be properly handled. Statements of such suggestions should be forwarded to the general manager, but to no one below him. These should then be referred to the staff, hereinafter to be described, for consideration and recommendation. If the result is an advantageous change in method, the exact advantage should be determined, vouched for by an outside auditor, and a certain percentage of the saving should be regularly paid to the originator thereof. In the event of death or of the individual leaving the employ of the concern, a settlement should be effected upon the basis of some such tables as are used in the computation of annuities. The following circumstances, however, should be taken into account: A subsequent improvement might nullify the former one and cause it to become obsolete. At such a time the payment of "dividends" upon the earnings effected by the former improvement should obviously be discontinued. In a word, the maker of a suggestion resulting in a commercial or industrial improvement should derive a similar advantage to that which a patentee derives, as long as the patent system is in effect.

At the present time the manager has generally a very incomplete staff of subordinates, who, to a degree, support him instead of being supported *by* him. He controls them by the issuance of orders or mere descriptions of desired results, which are gradually and imperfectly expanded into directions as they trickle down through the organization. The larger part of these directions, therefore, never pass through the manager or any other focal point. Hence the frequent recurrence of overlaps or gaps and of the conflicts of authority which are so familiar to everyone who has been connected with an organization of any size. The order has not been expanded into a competent direction, because the mental ability of the manager has not been so supplemented as to be capable of meeting the increased demand as to both the volume and variety of effort which are necessary to accomplish this result. As no man is omniscient, as no man has the power of grasping with absolute completion, by direct detailed study, even one of the many lines of knowledge, it is evident, in the formulation of even comparatively simple directions, that a wide variety, not only of the knowledge which youth may possess, but of the wisdom in its application born of the experience which only comes with years, is quite essential. Hence the necessity of supplementing the mental ability of the manager, in the formulation of his directions, with those of such other men as have definite knowledge of each of the different phases of the subject, and also the wisdom, born of experience, in the application of such knowledge is no less than that of supplementing his muscles in the performance

of the eventuating tasks. This quantitative supplementation of the manager's mental ability is the function which the scientist of the highest grade is eminently fitted to perform, but care should be exercised as to the manner in which the service is rendered. In the first place, the value of the service which the scientist is expected to render should be considered as in proportion to its intensiveness rather than its extensiveness. The specialist should, therefore, not be expected to take into account the modifying influence his service should have on that of others, or vice versa. As such influences, however, are very real, they will certainly exert themselves at some point; that point should be the mind of the manager, and the action should take place at the time when he acts as a digestor for the varied advice which it is the office of this group of scientists, known as the advisory staff, to furnish. The direct injection of flour, sugar, salt, etc., into the blood would work serious injury, but not more so, proportionately, than the direct, unmodified, undigested dictum of the scientist if introduced directly into the working organization. Hence the scientist, however able he may be, should not be given executive authority save only over such personal assistants as may be necessary to him in the study and research work essential to the formulation of his advice to the manager, to whom it should always be communicated. The scientist should be given the free run of the works with which he is connected. The most friendly relations should exist between him and all members of the line or working organization. But it should be clearly understood on all sides that he has no authority over the latter, and that they are not in any way responsible to him.

At least seven varieties of scientific advisers are generally necessary, several of these often being divided and sub-divided to a considerable extent, according to the nature of the enterprise. These men should be of as high standing in their respective branches as it is in the power of the organization to secure. Some of them need give only a part of their time to the work, while some others will probably have to give it their exclusive attention. In not a few cases it will be wise to transfer to the staff men who have had long experience in the line organization, although such would generally be most useful as assistants to the chiefs of their respective staff divisions.

The method of selection of these scientists is a matter of considerable importance. As the manager should be held responsible for results, he should be allowed to nominate his advisers, subject to the approval of the executive committee or board of directors from whom he derives his authority. This would make it impossible for an uncongenial situation to be created.

The compensation of these scientists should, naturally, be determined by the board or committee, just as in the case of the manager himself; but the attitude of such board or committee should be that of insisting that the powers of the manager should be properly supplemented rather than to exercise false economy in this direction, and also that of making the manager feel that it involved no personal reflection on him, but was rather a wise recognition of the general limitations of humanity.

It is the writer's belief that the scheme of organization, the routine for its operation, the detailed plan of finance, the lines upon which the sales campaign should be conducted, the design of the manufacturing plant, the original of each type of product and any important variations of the same, together with the statistical scheme, should all be worked out in rather complete detail by the staff. In connection with the product, the selection of equipment for the performance of the operations and the compilation of typical

time or energy studies should also be made by them, and they should study the effect of the product upon the community from a sociological standpoint, as well as the effect of surrounding conditions upon the workers. In short, the idea should be to utilize the highest grade of ability in the preparation of directions.

The position of manager, in itself, is a direct outcome of the evolution of the one-man enterprise into the corporation, the predominating characteristic of which evolution is specialization and the consequent benefits thereof. Even after the individual has secured the co-operation of others in the execution of his plans he has still to prosecute the research into possibilities, which is necessary for the formulation of these plans, as well as to perform the work of formulation itself. The increase in the volume of the demands on the manager has been erroneously met by his attempting to delegate a part of each of his duties rather than by delegating some duties entirely, while retaining others for his own performance, aided, perhaps, by close personal assistance of a highly expert and confidental character.

The manager at present, as we have seen, has almost instinctively learned to utilize the energy derived from other sources for the execution of his orders; but he has made the mistake of trying to secure, simultaneously and from the same individuals, the expansion of his orders into directions, together with the research work necessary for this result. It is now being realized that the next step which should logically have been taken was the delegation of the work of research to an advisory staff composed of highly trained specialists, as above described. The manager's most important duty may be properly compared with that of a stomach which is charged with the responsibility of digesting the food introduced thereinto, yet which the stomach does not itself create. The immediate result of this process is the formulation of competent specific directions as to the methods by which the results, which he has been authorized by the directors to produce, shall be attained. Hence the training of the manager should be such as to equip him to perform this particular function. He should endeavour to formulate his directions by the procurement, co-ordination and adjustment of the recommendations of the members of his advisory staff to each other rather than by doing his own research work. Then all the inconsistencies which inevitably result from the inadequate opinions of one man or the diversified opinions of several men considering a problem from different standpoints and with different trainings will be eliminated before the final formation of the working plans and of the directions for their execution.

It is true that in the exercise of his controlling function it is necessary for the manager to determine the efficiency of his organization by a careful comparison of the accounts or records of what has taken place with the directions as to what should have taken place. In the majority of cases at the present time even this comparison is not made because of the absence of standards for performance. Standards, however, do not necessarily include directions. The only comparison which is usually possible is that between the performance during one period of time with that during a preceding period. This is comparatively useless, not only because it does not occur until after the act has been performed, but because it does not take into account the actual possibilities of performance. A comparison with standards is only one degree better, but is still subsequent to the act, and, therefore, only of value in connection with a repetition thereof. The mischief, if any, has already been done. Hence all such retrospective considerations are of comparatively little value. The thing to do is to prevent rather

than to cure. The manager, therefore, should cultivate his foresight rather than his "hind-sight," and the prime requisite thereto is ample research work.

By reason, also, of the increased volume of the demands upon the manager, due to the increased volume of the entire business, it is found advisable that he should be provided with certain highly trained personal assistants, as well as stenographers and clerks, to aid in the physical performance of this digestive function. There are at least four sections into which this work may be divided to advantage, a full description of which is not within the province of this article. The work of defining the characteristics of these assistants and of allocating their duties, as in the case of all other members of the organization, is the province of an engineer skilled in the design of such machinery rather than that of the manager who is to operate it. The ability to operate does not, by any means, necessitate or involve the ability to design. The private secretary, being thoroughly acquainted with the details of his superior's business, together with the rules of composition, is able, after receiving general directions, to competently conduct the correspondence, and, in so doing, operates a typewriter. It is not at all necessary that he should be able to make the typewriter. Neither is it necessary or supposable that the competent mechanic who makes the typewriter should be able to conduct the correspondence. These two requisite abilities are absolutely dissimilar in character. In like manner the organization should be designed by one type of scientist—an engineer skilled in this particular line of work—and be operated by a manager who is, in fact, just as much a scientist, though with a different training.

Management, or the science of execution and administration, is something which requires a specific and distinct training, not simply a superior degree of skill in the performance of subordinate tasks; and our varied resources will not be utilized to their proper and full extent until this is generally and completely realized. The ideal manager should have a broad, liberal education rather than intensive experience in any one line, such as financier, salesman, producer or accountant. It is the writer's belief that no adequate foundation for the work is now being laid in any educational institution in this country. Here instruction in fundamental principles is of primary and in details of secondary importance. Great effort should be made to train a mind to analyze, to digest, to reason, to compare, to deduce, and, finally, to arrive at well-rounded, logical, wise decisions. Much attention should also be paid to the art of so communicating one's decisions to the mind of another, with regard to their degree of intellectual development, that the desired impression will be created and the desired result follow as a matter of course.

The second principal grade of scientists are those who, on account of their youth, or for some other reason, possess more knowledge than wisdom, and, hence, are most useful in the line organization. Here their lack of experience and its resultant wisdom are supplied by the careful directions which have been formulated by the general manager pursuant to the advice of his technical staff. The reason that an army is able to achieve results which are impossible to a mob is that each individual in the army centres his whole effort in an attempt to clearly understand and efficiently execute the directions which have been given him. In the case of the mob each individual endeavours to formulate the plans for his own action, as well as to perform it.

The scientist of the second grade should realize that the function of the line organization is, and must always be, operative rather than advisory. As long as he remains in

the line organization he must govern himself chiefly with regard to this principle. He must use his technical education as an aid in understanding and executing the directions which he has received to the greatest possible degree of perfection. When so engaged he should endeavour to free his mind from all attempts to formulate improvement upon these directions. His entire energies should be concentrated in the effort to comprehend the meaning of his instructions and to attain the desired result. During the subsequent period of rest his mind may, and should, endeavour to comprehend the principles underlying the instructions and to determine wherein it may be possible, if at all, to improve in their application.

The manager, in the past, having invariably considered all scientists as belonging to the second grade, has insisted—and not unreasonably—that they should follow his directions. The difficulty has been that his directions were not entirely competent, and the flaws which the scientists were able to detect caused them to lose confidence in the whole. In like manner the only scientists who would accept the conditions laid down by the manager, being chiefly second-grade men, generally exhibited a lack of wisdom which the manager was more easily able to realize than to remedy. Hence his respect for scientific knowledge did not increase. It is only when both scientists and managers are intelligently trained and selected for the positions which they are to occupy and when the duties of these positions are clearly defined and properly allocated that the results can be permanently satisfactory on both sides.

Each organization should be entirely permeated with the idea that the proper function of every business is to do its share in serving the surrounding community by the performance of some particular part of the effort necessary for the sustentation and enjoyment of life. When this is accomplished and the community is benefited, the organization, as a whole, is benefited, because it is a part of the community. In like manner each individual in the organization will prosper by the team play which brings about the prosperity of the organization.

MECHANICAL APPLIANCES ON THE PANAMA CANAL

III.—EXCAVATING EARTH AND ROCK AND HANDLING THE SPOIL

By J. F. Springer

AT one time the Suez Canal project came near to collapse because of the withdrawal of a great army of cheap hand labor. The French extricated themselves from their difficulties by having recourse to mechanical aids. To-day the extensive application of machine methods in great engineering undertakings is a matter of course. Indeed, the possibility of construction within reasonable limits of cost may often turn upon the question as to whether mechanical appliances suited to such work are available. A great construction enterprise may be the occasion of developing new apparatus and new methods which afterwards become a part of well-recognized practice. The construction of the Chicago Drainage Channel was, no doubt, an example of this. However, the developments of mechanical aids may go on more slowly, and, perhaps, more surely. When the Panama Canal was taken over by the Americans in May, 1904, a great deal of mechanical development, which has since proved of great service, had already taken place in a quiet way. The impulse of this development is to be found in the enormous aggregate of construction work which had been going on during the previous years—especially in the United States. On the other hand, the needs of the canal have stimulated invention, so that the world will be the richer because of the great work going on upon the Isthmus. An example of a piece of mechanism taken hold of and utilized by the builders of the canal, which had nevertheless received its development independently, is the steam shovel. Perhaps the canal could be excavated without it; if so, the proposition would have been a wonderfully different one. The steam shovel is excavating the Culebra Cut at the rate of about 54,000 cubic yards per day. It is no wonder then, that the greatest piece of dry digging ever undertaken by man is being accomplished with great certainty and dispatch.

The French seem to have begun excavation upon the 20th of January, 1882, and to have stopped some time in 1889. They resumed work in 1895, and continued until the Americans took charge in 1904. Counting the total excavation performed by the French in Culebra Cut as 25,000,000 cubic yards, and estimating that they accomplished this in 7½ years (1882-1889), we have an average of less than 11,000 cubic yards per day. The Americans had been excavating for about the same length of time upon June 30, 1911. But their daily average was more than 29,000 cubic yards per day, and it is now nearly double this amount. Unquestionably, the modern steam shovel is entitled to a very large share of the credit that is due. The French were, no doubt, using mechanical means. But the excavating apparatus of the eighties and the shovel of 1904 are very different things. During the month of January, 1906, there were in Culebra Cut an average of 12.83 steam shovels. These had an average daily output of 363 cubic yards. In April of the same year, the average output had nearly doubled, although that April was an exceedingly wet month. The rainfall for the cut amounted to nearly 10 inches, as against less than 1¼ inches

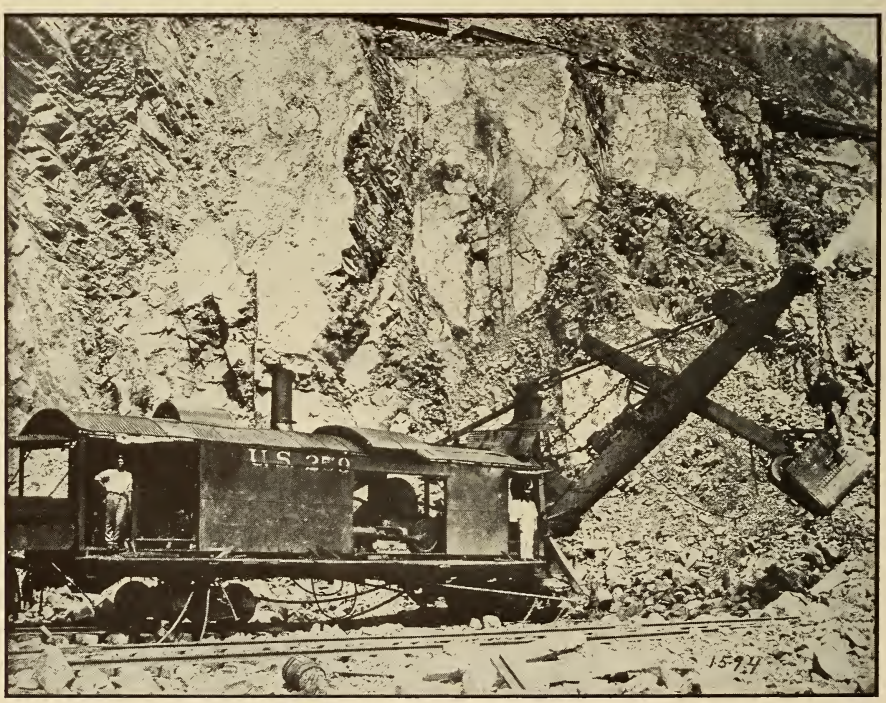
for January. In August the number of shovels was 16.93, and the average daily output 536 cubic yards. The rainfall amounted to nearly 12½ inches; the temperature (in the sun) rose to 132 degrees (Fahr.). By December, 1907, the average daily performance amounted to 955 cubic yards per shovel. There were then 42.72 shovels working in the Culebra Cut district. But individual shovels must

SULLIVAN DRILLS AT WORK IN HARD ROCK NEAR BAS OBISPO, IN THE CULEBRA DISTRICT

have been greatly exceeding this. For example, shovel No. 222 handled between 7.10 and 9.35 A. M., a total of 1,140 cubic yards of material. This corresponds to an hourly average of 419 cubic yards. In the following month, Dec. 18, this same shovel handled 2,072 cubic yards of rock and earth. It should be remembered that while a steam shovel has steam up for eight hours per day, it is not actually operating during the whole of that time. A great deal of time is, in fact, lost because of the necessity to change position, to wait on blasting operations, return of empty cars, etc. A portion of this delay properly belongs to the shovel, because necessitated by it. Thus, the moving forward to take a new position is to be regarded as a delay properly charged to the shovel itself. But when the machine has to wait for empty cars, that is a debit belonging elsewhere. But good as the shovel record of 2,072 cubic yards undoubtedly is, it was exceeded on Dec. 13 at Pedro Miguel by shovel No. 211, which on that day handled 3,164 cubic yards. The material in the latter case was classed as "soft rock"; and also by shovel No. 205, which on Dec. 21 handled 2,140 cubic yards of rock and earth. We hear from shovel No. 222 again as having handled in the 25 working days of January, 1908, a total of 45,788 cubic yards of rock. Shovel No. 232 beat this record by handling 46,496 cubic yards in the same time; but over one-fourth of this amount

was earth. The daily average of these two pieces of apparatus was 1,832 and 1,860 cubic yards, respectively. The daily average for the month of 1,832 cubic yards shows that the record of 2,072 cubic yards for a single day was, previously made by the same shovel, no mere "flash in the pan." The following month, Feb. 14, the very same shovel, No. 222, handled 2,916 cubic yards of rock and earth. The daily average of the 43.67 steam shovels throughout Culebra Cut was, in February, 1,186 cubic yards each. In July, 1908 (26 working days), steam shovel No. 262 handled 53,440 cubic yards of material, 95 per cent. of which was rock.

Steam shovels vary in size and capacity. Thus, the largest shovels weigh 100 tons or more when ready for work; and the capacity of the dipper is about 5 cubic yards. Another size has a dipper of about half this capacity, the whole apparatus weighing about 70 tons. Still another size has a dipper with a capacity of 1¾ cubic yards, the weight of the whole shovel being about 45 tons. Seventeen shovels of the 100-ton size, which, on Aug. 12, 1910, were working in the Culebra district, excavated a total of 28,249 cubic yards. These machines were actually engaged at their proper duty, upon an average of 6 hours 12½ minutes per day. As the average amount of excavation per shovel was 1662 cubic yards, the average hourly performance was 267.7 cubic yards of excavation. That is to say, each shovel was working at a rate which would have enabled it to load 133.8 two-horse wagons per hour, or a two-horse wagon load every 27 seconds. Even if we include the time lost in waiting for cars, which was about 1 hour 9 minutes on the average for the day, the shovels were each working at a rate competent to load a two-horse wagon in 31 seconds. As this example takes in 17 shovels, it may be regarded as a fair showing of what these monster machines are capable of when handled by men of skill and energy.



MARION 75-TON SHOVEL HANDLING BLASTED ROCK

EXCAVATION IN THE CULEBRA CUT WITH THE 95-TON BUCYRUS STEAM SHOVELS. THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN

It is interesting to note that weather conditions have only a limited effect upon the work of the steam shovel. On Oct. 1, 1909, occurred one of the heaviest downpours of rain on record in the Culebra Cut district. At Empire, on the north side of the 9-mile excavation, about four miles south of the northern end, 3.52 inches of rain fell in one hour. During the following four hours another inch was added. North and south the storm seems to have been less severe. The region of the Cut was drained to the north and south from a divide about half way between these ends. At Bas Obispo, at the north end of the Cut, a sump had been provided to receive the water

BUCYRUS STEAM SHOVEL EXCAVATING NEAR SAN PABLO, BEFORE A BLAST

from the northern drainage area. After the five-hour shower was over, the water level in the sump was higher than that in the Chagres River. No steam shovels in this region were at work. The sump was caused to drain off somewhat by opening the flood gates and permitting water to flow into the river. The pumps, which had been flooded, were soon gotten to work, and through the night worked at their capacity of 15,000 gallons per minute in lowering the water level. The steam shovels at Bas Obispo re-

INGERSOLL DRILL AT WORK ON THE PANAMA CANAL, PARAISO. THE INGERSOLL-RAND CO., NEW YORK

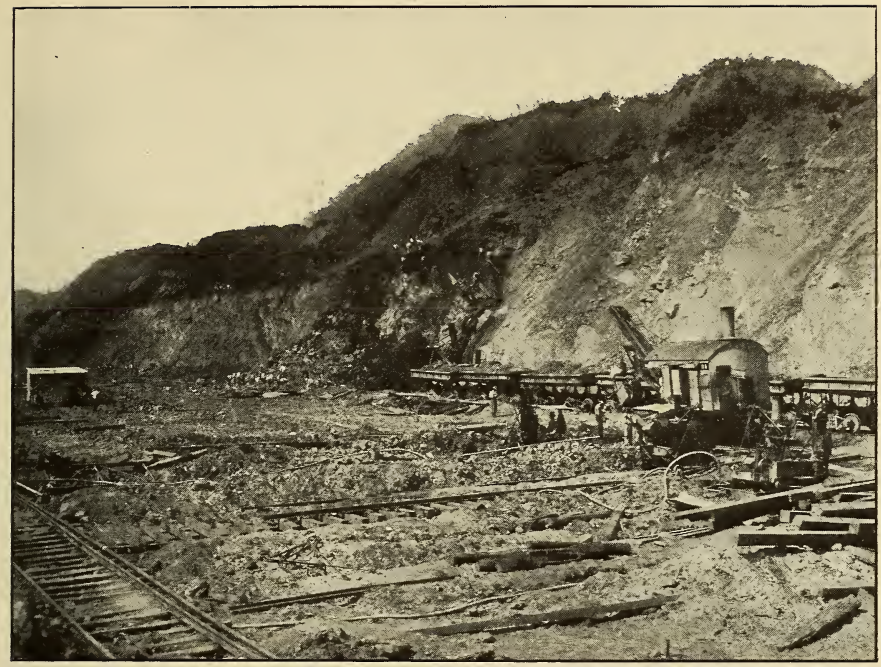
INGERSOLL-RAND DRILL AT WORK AT THE ISTHMUS

sumed work at noon of the day following the shower. On the day of the shower, the yardage of the 40 shovels in the cut was reduced less than 23 per cent. from what it had been the day before. On the day following, the yardage was within 18 per cent. of what it had been. The total delay on account of the shower amounted to 82 hours, a little more than 2 hours per shovel. At 5 o'clock, when the shower had only just about ceased, the blasting ahead of the shovels was resumed. "When the heaviest part of the rain was over the shovels resumed work, and, indeed, when the cut was obscured by the sheet of falling water, the spoil trains could be heard picking their way up to the shovels and starting for the run to the dumps."

HANDLING SPOIL

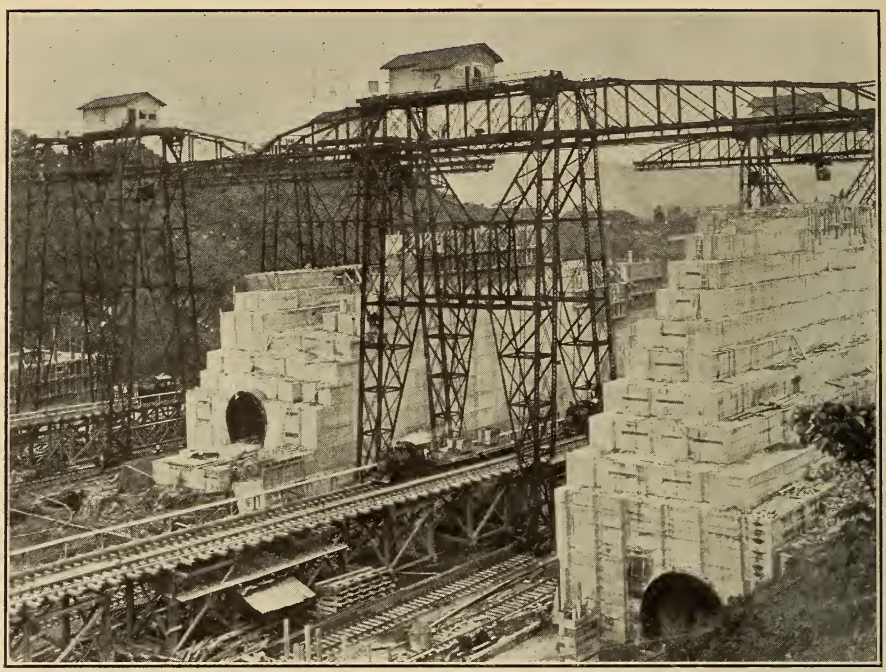
It will be granted that a shovel or any other excavating apparatus is limited in its performance by the comparative perfection of the methods and means of disposing of the spoil. When a 100-ton shovel plunges its great dipper into a mass of blasted rock and brings 4 or 5 cubic yards of it up clear it is necessary to receive and dispose of this material without delay. At Culebra Cut this matter is taken care of by railway dump trains. Culebra Cut runs through the dividing ridge between the Atlantic and Pacific. Dumping grounds were early provided on each side. The conditions at the cut itself and at the dumps were probably typical in the summer of 1908. At that time the tracks of the dump trains were so arranged that they ran upgrade from each end of the great 9-mile-long excavation to a midway point forming a kind of summit. The transportation was so managed that the movement of a train was always down whenever it was partially or completely loaded. The northern section of the cut, whose trains always departed northwards for one of the five dumping grounds, had twenty-one shovels engaged in loading cars on fourteen tracks. As the *Canal Record* informs us, a train of empty cars would come into the cut on an upgrade track until it reached the summit. There it would begin its return on a down-grade track. It would run down alongside a shovel and receive material from it. In case a number of shovels were loading onto the same track, the train would delay near the shovels towards the south until another train of empties would come up. It would then move further down, and so permit the new train to come into position. If there should be other shovels down the line, it would receive spoil from them before going on to the dumping places.

MARION STEAM SHOVEL BURIED IN A LANDSLIDE AND BEING DUG OUT BY A COMPANION SHOVEL
The buried shovel was practically uninjured

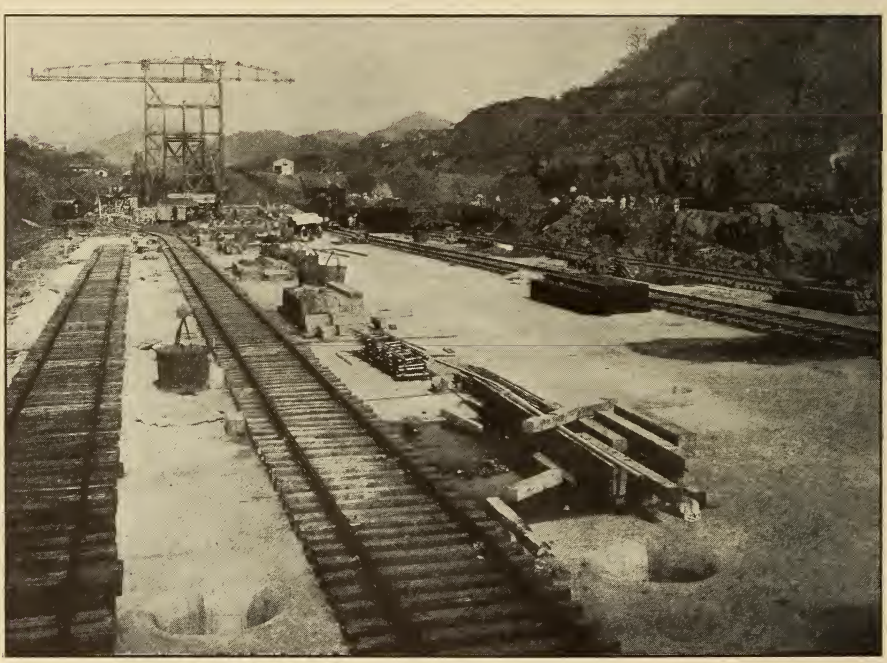


CLEARING A LOCK SITE. SULLIVAN CHANNELERS CUTTING WALLS FOR CULVERT TRENCHES

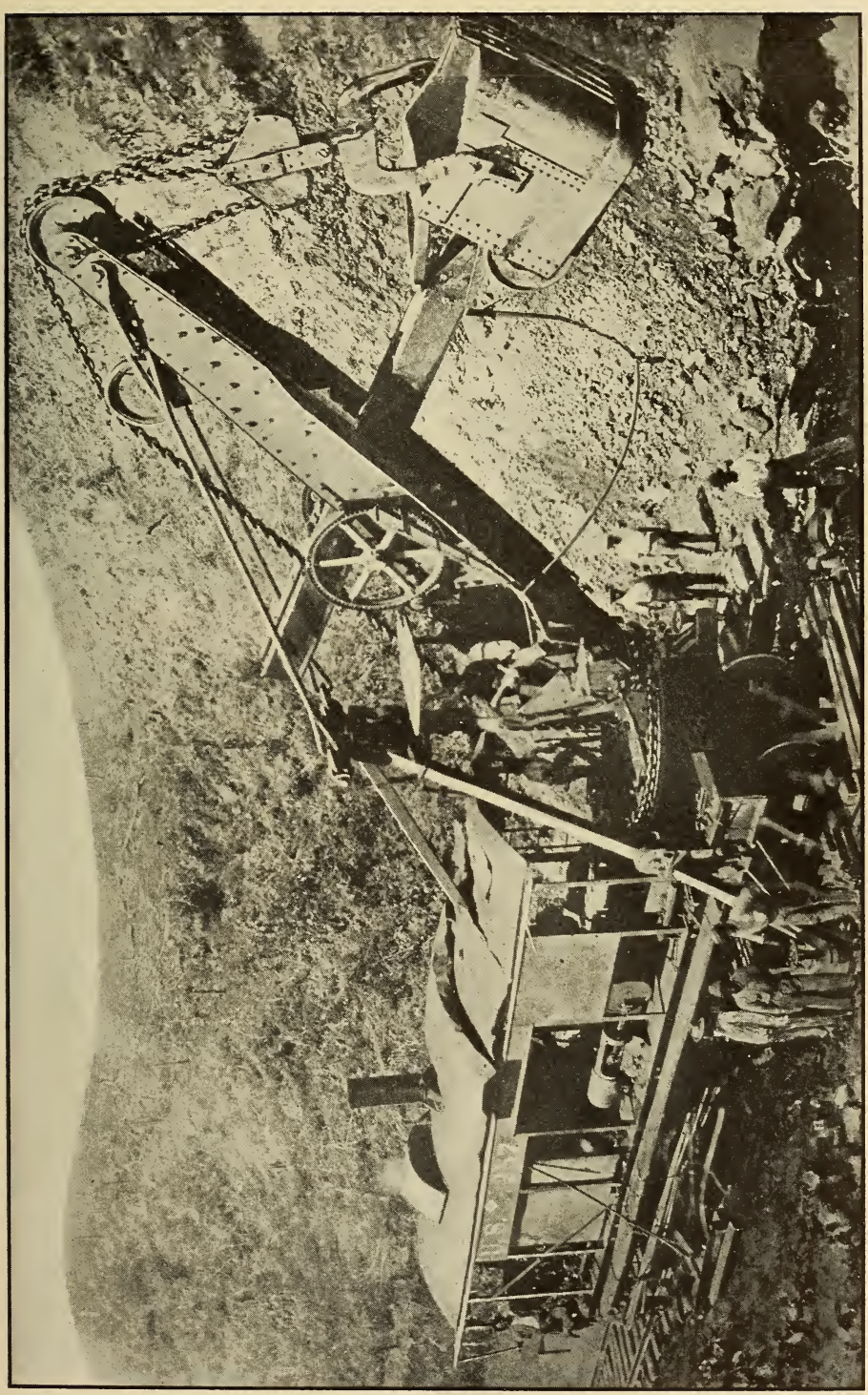
LOCK SITE WITH TRANSVERSE CULVERT TRENCHES CUT IN THE FLOOR MADE BY THE SULLIVAN CHANNELING MACHINES



WELLMAN-SEAVER-MORGAN CHAMBER CRANES, DRIVEN BY WESTINGHOUSE ELECTRIC MOTORS, PEDRO MIGUEL LOCK



FLOOR OF PEDRO MIGUEL LOCK, SHOWING INLETS TO CULVERTS CUT BY SULLIVAN CHANNELERS



THE RECORD-BREAKING MARION STEAM SHOVEL IN THE CULEBRA CUT

THE LIDGERWOOD RAPID UNLOADER

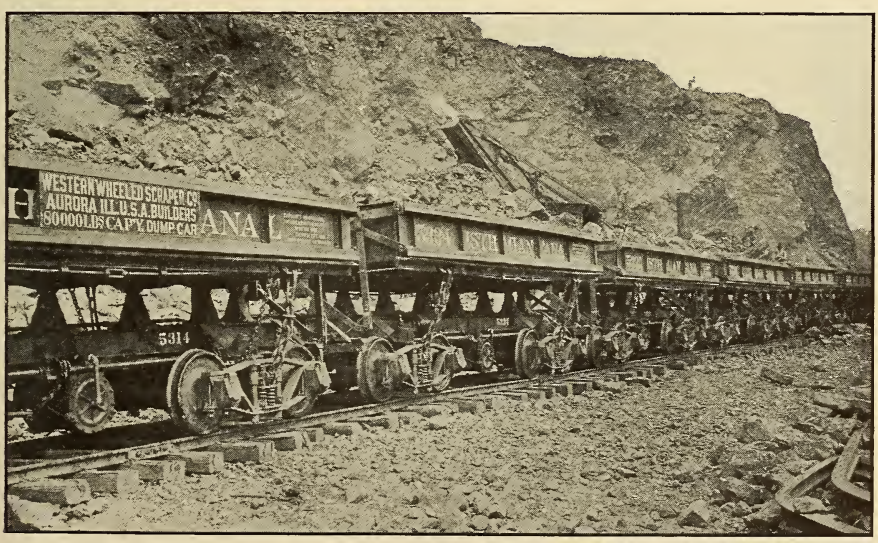
THE DUMPING GROUNDS

The chief location where dumping took place was the Tabernilla dump. Here were six dumping locations. The trains taken to Tabernilla were all made up of one pattern of car, known as the Lidgerwood car. These are ordinary flat

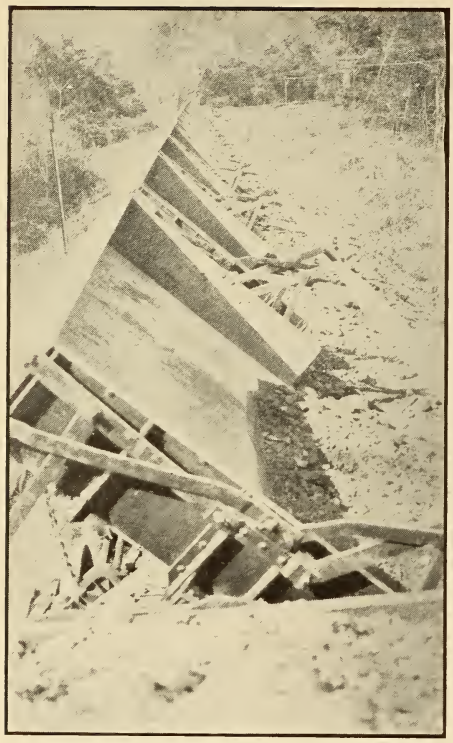
THE LIDGERWOOD PLOW CLEARING A DIRT TRAIN

A TRAIN OF DUMP CARS. WESTERN WHEELED SCRAPER CO., AURORA, ILL.

cars provided with a guard on one side, the other side and the ends being left open. Aprons extend from one car to the next throughout a train, and thus make the floor continuous for the whole length. Such a train is loaded with a single continuous pile of spoil. When a train of this character arrives at Tabernilla with its load the locomotive is disconnected and leaves the train in charge of a dump engine. A typical method of unloading is as follows: Between the dump engine and the train is a special car, on which is arranged a Lidgerwood winding drum and engine. The whole train is moved up to the point of entrance upon the actual dumping positions. Here a chain is stretched across the



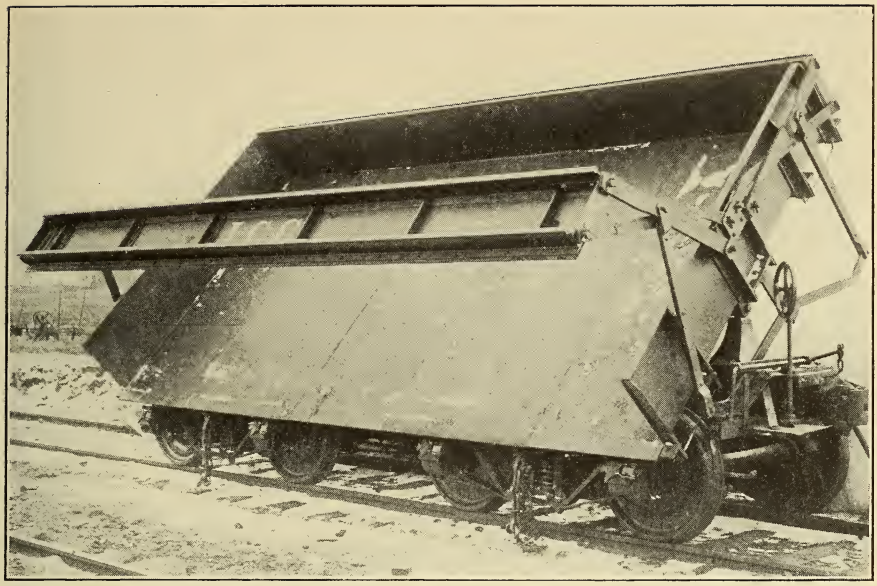
A LINE OF WESTERN DUMP CARS ON THE CANAL WORK



DUMPING THE SPOIL

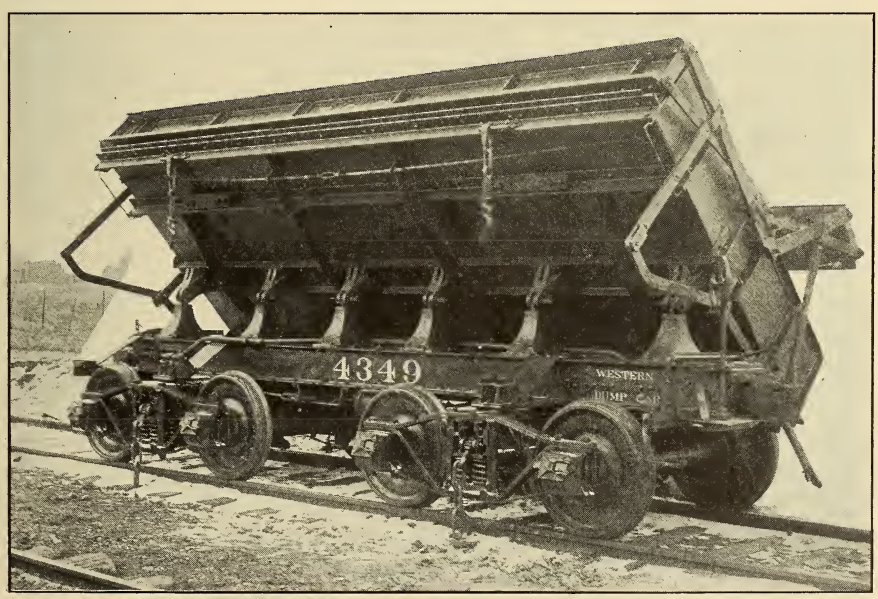
train just back of the car containing the winding drum, the ends of the chain being secured to two suitable poles arranged one on either side of the track. The free end of the steel cable on the winding drum is now attached to the transverse chain. The dump engine now goes forward, carrying the train with it. The winding apparatus permits the cable to unwind, to accommodate the forward movement, which continues until the rear of the train has arrived at the two poles. The cable now extends all along the pile of spoil. The end which has been secured to the transverse chain is now unfastened and attached to a great plow, carried on a separate car. This plow has a single face extending obliquely across the floor of the train inside the single board on the side. The train itself in now in the desired position on the dumping spot. Actual unloading is now accomplished by operating the winding engine and drawing in the cable. The plow is drawn along the whole train, its great weight and its form being sufficient to maintain it in proper position as the plowing goes on. The spoil is shoved off the train on the open side and falls in a long ridge close up to the track. This is a typical operation of the celebrated Lidgerwood unloading procedure.

The pile of spoil along the track has now to be gotten over the edge of the dump, which is accomplished by means of a spreader. This is a device of the character of a plow, arranged on a special car. The plowshares of the spreaders may be drawn up on the car into a suitable position for moving around when not operating, or they may be let down at will into the operating position. The spreader is pushed along by a locomotive and deals with the pile of spoil on the ground in much the same way as the unloading plow dealt with it on the train. As the unloading and plowing off continue, the edge of the dump recedes from the track, until finally the edge is too far off for the spreader. This situation is met by shifting the railway track over towards the new edge. It is not necessary to lay a new track, but a short length of the old one is simply picked up, the rails and crossties all clinging together and being shifted in the direction desired. This procedure is continued from point to point until the whole length which is desired to relocate has been shifted somewhat. If the shift is not sufficient the procedure is repeated. At Tabernilla this method of relocating was, and probably still is, carried out by means of a mechanical contrivance designed by Mr. W. G. Bierd. This consists essentially of a special car provided with two booms and a winding apparatus. The two booms project from the rear. The one, which is nothing more nor less than a derrick boom, is kept at a desired elevation by a guy rope, rod or chain, which is secured to an A-frame



TOP VIEW OF WESTERN DUMP CAR

set up at the rear of the car. A block-and-tackle arrangement depends from the outer end of the boom, and is operated by a line running over a wheel or pulley on the A-frame. The block is furnished with a hook carrying a ring, which is a common end link for two short lengths of chain. The free ends of the chains are provided with hooks, by means of which they may be temporarily secured to the two rails of the track. By operating the line, the track will be lifted clear of the bal-



THE TIPPING MECHANISM OF THE DUMP CAR. WESTERN WHEELED SCRAPER CO., AURORA, ILLINOIS

A TRAIN OF DIRT CARS WITH LIDGERWOOD UNLOADER

last. The other boom extends out and off to one side in a horizontal plane. A line running over the end of this boom supplies the means of performing the shifting operation when once the track has been lifted and the line attached. Operating with this machine, it is not necessary even

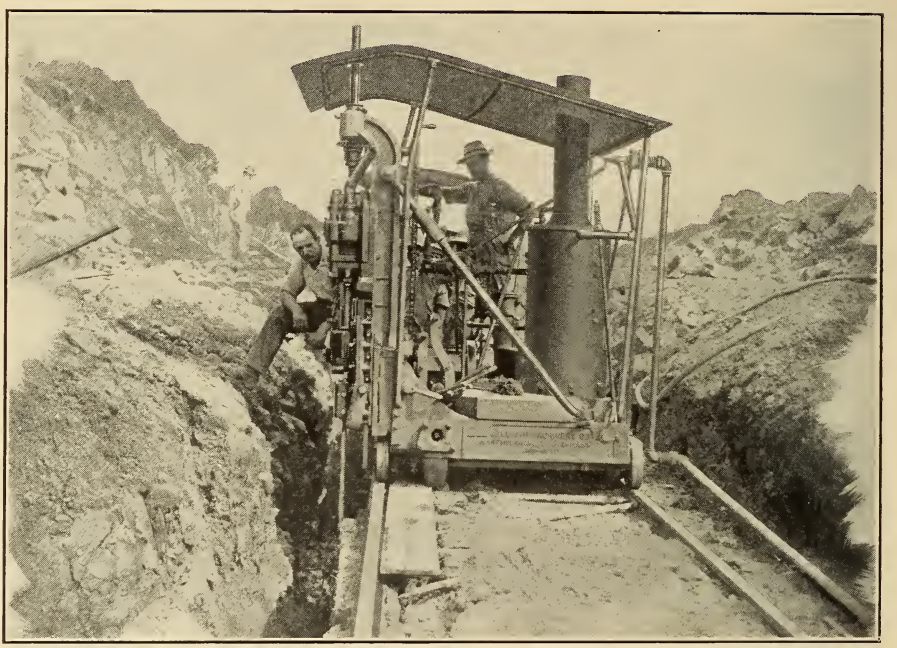
DOUBLE CANTILEVER BERM CRANE FOR HANDLING CONCRETE. BROWN HOISTING MACHINERY CO., CLEVELAND

to disconnect the rail lengths from each other. If a 15-foot length of track be lifted, a lateral shift of 4 feet can ordinarily be made, so it is said. It seems that it is not always, or perhaps generally, necessary to lift when operating a second time in order to shift more than the 4 feet. A single outfit, accompanied by nine men, is competent to shift 1 mile of track 4 feet in a working day of eight hours. The cost is estimated at about 15 cents per rail length, omitting the expense involved in full and the wear and tear of the apparatus. It is said that by the ordinary method a force of 250 men and 3 foremen would be required, and that the cost would be about $2.55 per rail length. The apparatus runs ahead of the work on the unshifted track. Five track-shifting machines relocated in the month of October, 1908—which had four Sundays—a total of 78.8 miles of track. This implies a monthly average of 15.76 miles per machine, or a daily average per machine of 0.584 mile. One of these machines shifted a total of 23.7 miles a daily average of 0.878 mile. At one dumping point—Tabernilla—a total of 34.2 miles of track was shifted during the month. As this implies a relocation of 1¼ miles of track per day, we may get an idea of the rapidity with which the dump piles were growing.

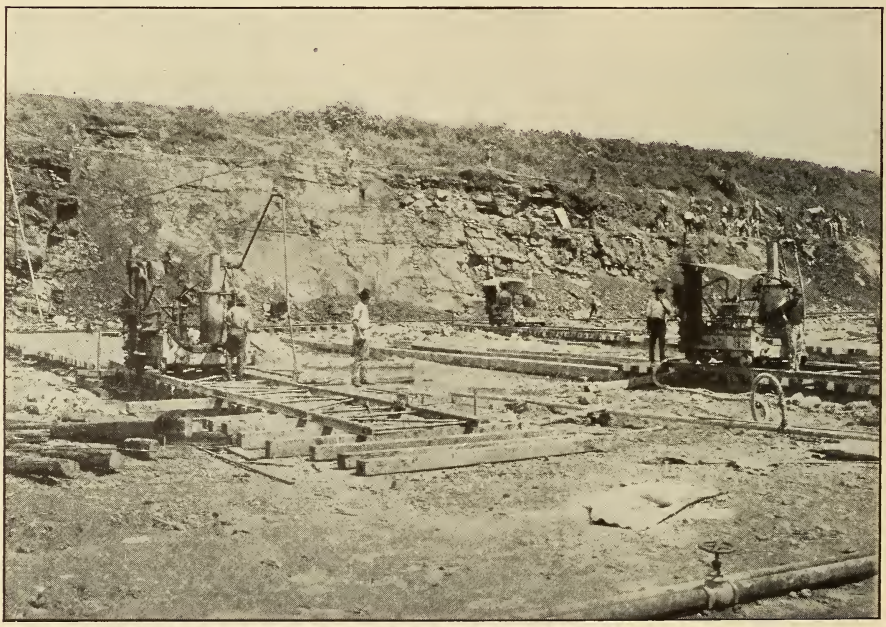
Improvements in the track-shifter made during the progress of the excavation work on the canal have been such as to produce a machine which is capable of throwing the track 9 feet horizontally at a single operation. One shifter at Tabernilla dump in the spring of 1910 shifted 1¼ miles of track 12 feet in 110 minutes.

When once the track has been shifted over to the new edge of the dump, the unloader and the spreader may take up their work again at this particular point. The distance in 1908 of these dumps at Tabernilla from the summit of the tracks in

THE BUCKET OF A BUCYRUS STEAM SHOVEL IN ACTION



SULLIVAN STONE CHANNELING MACHINE, OPERATED BY COMPRESSED AIR AND FITTED WITH AIR REHEATER



ROCK CHANNELING MACHINES AT WORK ON THE UPPER MIRAFLORES LOCK SITE. SULLIVAN MACHINERY COMPANY, CHICAGO

Culebra Cut was 14½ miles. On a typical day 50 trains, each containing sixteen wooden cars, having a capacity of 20 cubic yards each, would be unloaded by the plowing method at Tabernilla alone. This amount of work was performed by four unloaders—that is to say, a single unloader was capable, upon the average, of unloading 4,000 cubic yards per day, or 500 cubic yards per hour. This means unloading at the rate of 3¾ cubic yards per second. At Tabernilla there were, in addition to the four unloaders, two spreaders, two track-shifters, one pusher engine and one switch engine.

The spreader was used elsewhere, as well as at Tabernilla, in connection both with unloaders and dump cars. Thus, on the north slope alone, ten locomotives were engaged in hauling the special type of dump cars furnished by the Western Wheeled Scraper Company (Aurora, Ill.). Eight miles from the summit was the dumping ground of Gorgona. Here eight trains of twenty-five dump cars each would discharge their loads. As the cars had a capacity of 17 cubic yards, we have a daily total of 3,400 cubic yards brought in this one type of car to this one dump. At Mamei, ten miles away, both large and small Western cars were dumping 1,500 or 1,600 cubic yards per day. And so also at other points. Three trains of large dump cars were being run daily from Bas Obispo to the site of the great dam, carrying 1,200 or 1,300 cubic yards of rock to be dumped onto the south toe of the structure. This haul was one of 24 miles.

The transportation equipment for use in the work of Culebra Cut was equal to that of a small railroad. There were 135 locomotives, 1,500 Lidgerwood cars and 430 Western Wheeled Scraper Co. cars. About two-thirds was employed on the north slope.

(To be continued.)

COMBINATION DESIGNS OF MACHINE TOOLS

By Joseph Horner

A VERY characteristic aspect of machine tool manufacture in recent years has been that of the large number of machines introduced to perform one operation only, or one principal operation and a very limited number of subsidiary ones. These machines have found their way into nearly every shop of note and have become very potent factors in reducing the cost of production, and also in many cases of increasing the accuracy of the work done. Consequently these specialised machines are regarded with much favour and the value of the older combination designs of machines has lessened proportionately.

It is in human nature generally to go to extremes, and in this matter the mistake is sometimes made, first of supposing that a machine which is useful under a certain set of conditions is equally serviceable in those of a different kind. Second, that any labourer, handy man, or boy, can operate an automatic or semi-automatic machine, and that given the possession of such a machine, certain advantages in output and character of workmanship done on it must inevitably follow. If, however, these natural errors of judgment are avoided, born of absence of experience, the special machine tool should undoubtedly have preference over the general tool when the volume of a given class of work is sufficient to keep it fully or even fairly constantly employed. This is the way in which the subject should be regarded by the management. An alternative would be to sublet work of a very special character that is only required occasionally or in limited quantities.

Combination designs of machine tools are naturally not regarded with much favour in the large modern machine shops, where the tendency is rather to employ those highly specialised designs, because differentiation increases in these shops. Hence the smaller the firm, provided its line of manufacture does not consist of specialties, the greater is the value of the combination machine. Space and capital alike being limited entail restrictions in outlay. For the principal consideration which determines the purchase of machines that combine several functions is the saving in capital outlay and the limitations of shop room. The work done on these is rarely of a highly specialised character. If large quantities of an article are required, a special machine tool or machine tools should be laid down to deal with these alone. But for all besides, machine tools of a more or less combination or inclusive character are employed. Small shops, however, deal sometimes with very highly specialised products, and when that is the case they will be equipped wholly with the best and most highly specialised machine tools available. Gear cutting establishments are the most familiar instances of this kind. On the other hand the big shops which are divided into departments often employ both kinds of machine tools.

Work which is done on combination machines may be classed either as related, or unrelated. Regarded in this aspect the terms may have reference either to kindred or allied operations, or to operations in which

the relation is only that due to the size of the pieces treated. A third grouping would be that of additional attachments to a standard machine, which may be regarded as of the nature of an excrescence to be attached occasionally only.

The examples of combination designs of machines which perform operations of an allied or similar character include general grinders, some of the universal tool grinders, the universal gear cutters, many drilling machines, vertical boring and turning mills, many milling machines, the turret lathes, some planing and shaping machines. Boring and turning are exemplified in the wheel and tyre lathes of the railway and wagon shops. Operations which are related only in regard to the size of the work involve the use of machines in which combinations are included chiefly or only with the object of avoiding resetting of massive pieces. Thus, holes are drilled and tapped, or they are bored, and surfaces are milled at right angles. Some planing machines include also provision for milling. But the same object may be sought when small pieces done in quantities are concerned, as in turret lathes. Combination machine tools which are designed to avoid putting work on more than one machine are in direct opposition to that principle of specialisation which seeks economy in boring in one lathe and turning in another, or roughing down by milling in one machine and finishing by planing in another, or rough-turning or planing or milling in one machine and finishing by grinding in another. But each is consistent with the ultimate object sought, that of tooling with the highest economy and accuracy. The examples of attachments to standard machines are extremely numerous. They scarcely admit of classification. They occur in nearly all kinds of machine tools and are usually in some degree of a makeshift character, not, therefore, the best possible, but the best which can be done under the circumstances. They are cousins-german to the temporary rigs-up which men make to supplement or extend existing machines, to enable an occasional job to be done which lies outside the normal range of the machine. That is their function, only they are fitted more neatly to the machine than the temporary fittings just named.

When there is no objection to the inclusion of the provision for performing several operations in one machine, there is a strong argument for doing so. The floor area occupied by the one machine by comparison with that required for several is well worth consideration when shops tend to become overcrowded. The framings and certain mechanical movements also are economised, as one base or bed, one driving pulley, motor, or main shaft. Though the number of detached parts, and of provision for adjustments has to be multiplied, the main essential elements of the machine may be unaffected. Thus, for example, the change from drilling to tapping, and from drilling to boring, or milling, does not affect the main elements in any material degree, but chiefly entails gear changes to alter the speeds. On a universal gear cutter or grinder the main elements remain, but the movements are increased, and there are more attachments by comparison with those required in machines that perform one or two functions only. A combined spur and bevel gear cutter may well be mounted on one bed. The difference between a semi-automatic turret lathe and one which is fully automatic does not affect floor area occupied, but only the multiplication of details, and these chiefly in cam and chuck movements. The three and four-spindle automatics are much more highly developed than the common single-spindle designs. The essential difference is only a matter of repetition of similar parts, without material increase in over-all dimensions. The multiplication of tools in turrets may range from four to twenty, and

many of these are elaborated tool boxes comprising more than one tool, some or each having independent movements of their own, distinct from the sliding imparted by the turret. The size of the lathe itself is not increased, but its capacity for work is greatly extended. In the multiplication of boring spindles—two. three, or four, in number, and of drilling spindles even to a much greater extent, each is a copy of the rest. The vertical boring and turning mills having two tool bars and an additional turning tool at one side utilize the same main framing with a small necessary extension. Planing machines and plano-millers may have two tools on the cross rail and one or two at the sides without material increase in dimensions.

Some combinations which might be desirable are not very practicable. There must be congruity in the operations performed on one machine. Grinding on a lathe or other machine using cutting tools is almost unthinkable now. The union of reciprocating and rotary tools, such as milling and slotting, or as milling and drilling on a planing machine, though frequently included, duplicates the operating mechanisms of dissimilar kinds. Light drilling and heavy boring cannot be economically done from the same spindle. The addition of a planing or shaping device to a lathe is only a concession to amateurs. Boring or milling in a common lathe are practicable, and often done, but they do not harmonise with the present ideals of the machine shop and turnery.

An objection to highly elaborated combination machine tools is that with the multiplication of details the risks of inaccuracy increase, consequent on the weakness of some parts, and the wear of all. In a tool designed for a single kind of operation these can be minimised to the last degree, but not so when the details become very numerous, in which case compromises have to be made.

Some selected examples of combination machine tools in this article will illustrate some of the foregoing observations.

An early combination of allied

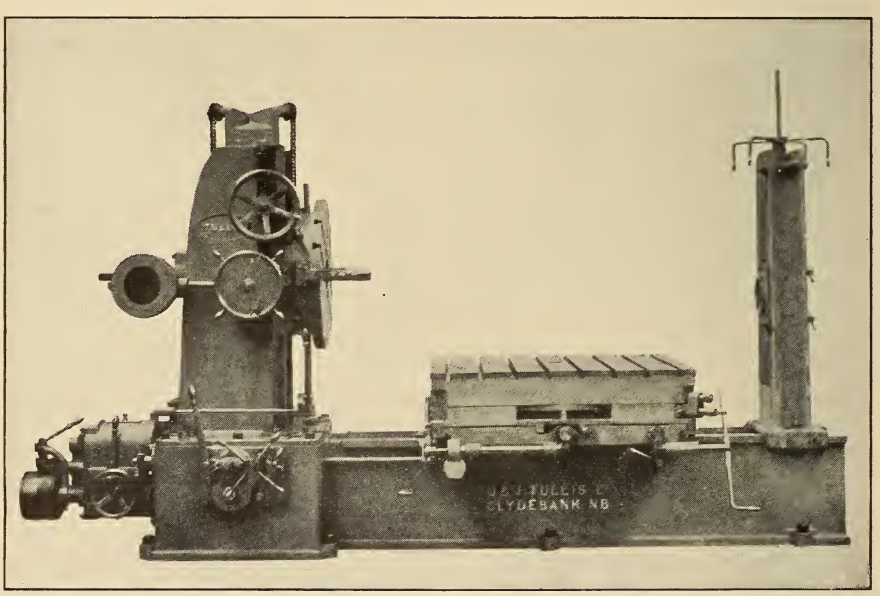


FIG. 1.—HORIZONTAL BORING, FACING, DRILLING AND TAPPING MACHINE. D. & J. TULLIS, LTD., CLYDEBANK, N. B.

operations was that of tapping and studding with drilling, boring, and facing. Previously, tapping by hand followed the drilling with consequent great waste of time. Almost all drilling machines now, excepting those of small dimensions have a set of gears for tapping and reversing, which follows on the drilling of the hole while the work remains in position. Many big machines also include provision for the insertion of studs. The work of boring and facing is included in drilling machines of medium and large dimensions. But the gears are not adapted for heavy boring of large diameters, for which the regular boring machines must be used. But the boring of small holes occupies a large sphere in pieces of work where drilling is also done, as in framings and cheeks of many kinds, and in machine tool framings.

Fig. 1 is an example of a heavy machine, weighing six tons, which combines drilling with tapping, and facing with boring. The column which is double to provide a central thrust, carries the spindle and its saddle. The bed carries the work table, and an upright to receive the free end of a boring bar. The spindle, 2¾ inches in diameter, clears the top of the table by 4 feet, when in its highest position. It can be traversed 18 inches. Its slide is counterweighted. The table can be traversed 5 feet 6 inches in front of the spindle. The compound table measures 4 feet square. Its cross traverse is 3 feet 4 inches by hand or power. It is revolved by worm and wheels and has positive stops at four positions for setting work at right angles. There are twelve changes of spindle speed by motor

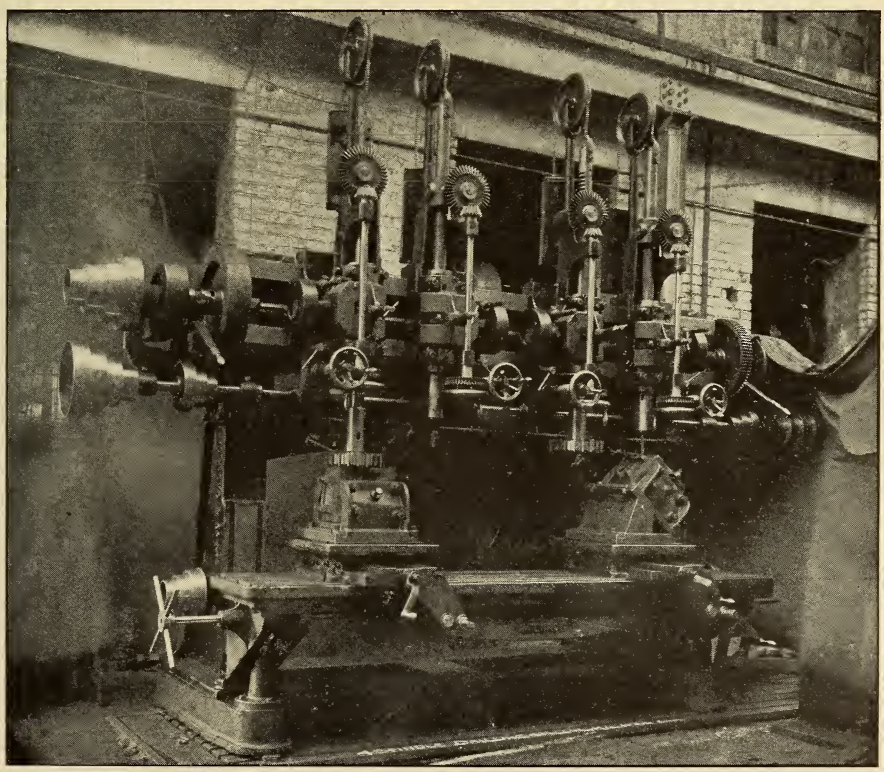


FIG. 2.—FOUR-SPINDLE DRILLING AND MILLING MACHINE. MESSRS. JOHN HOLROYD & CO., LTD., MILNROW, NEAR ROCHDALE

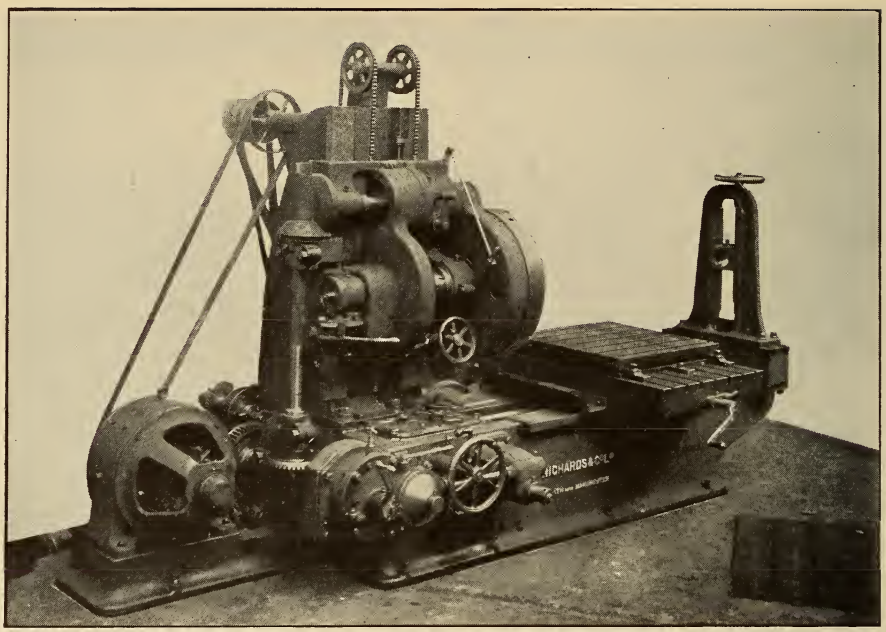


FIG. 3.—UNIVERSAL FACING, BORING, DRILLING AND MILLING MACHINE FOR HIGH-SPEED WORK. MESSRS. GEO. RICHARDS & CO., LTD., BROADHEATH, NEAR MANCHESTER

drive through gears. The speeds range from 30 to 372 revolutions per minute. These gears are of steel, case hardened, and run in oil. The spindle can be started, stopped, and reversed by a lever. There are six feeds, ranging from 24 to 120 cuts per inch, which can be changed instantaneously. Also a hand feed and a quick withdrawing motion. This machine is by Messrs. D. & J. Tullis, Ltd., of Clydebank, N. B.

A machine which combines three allied functions, that of drilling, tapping, and milling, so avoiding resetting the work, is illustrated by Fig. 2, one built by Messrs. John Holroyd & Co. Ltd., of Milnrow near Rochdale, It is designed for tooling railway carriage and wagon axle boxes, two of which can be under operation at one time. Two spindles perform the drilling and two others carry the end mills, which face at exact right angles to the drilled holes. One spindle in each pair of heads is arranged for tapping. Each spindle can be started, fed, and stopped independently of the others.

The general design can be noted in the photograph. Two uprights or housings are bolted to a baseplate. The housings carry a table below and across slide above along which the spindle heads are adjusted by hand, the movements of each being independent of those of the others. The spindles, 3 inches in diameter, are driven by two 5 horse-power electric motors located at the back of each upright, each of which drives through gearing one pair of spindles at speeds ranging from 15 to 45, and 66 to 200 revolutions per minute. Each spindle is provided with a quick and a slow hand feed, and a self-acting down feed. The latter is derived from two four-speed cones seen at the left hand. One set feeds two of the spindles, the other set the other two spindles. The feeds are 65, 110, 180, 300 cuts per inch, the maximum being 12 inches. The largest hole which can be drilled is 3 inches. The minimum centres of the pairs of spindles is 10 inches, the maximum 2 feet 6 inches. The maximum centres of the outer spin-

dles is 7 feet 3 inches. The table arrangements comprise a vertical adjustment of 16 inches to the main table, two auxiliary tables, each 19 inches square mounted on it, with cross traverses of 20 inches, and self-acting cross feeds for milling of 7 to 120 cuts per inch, with twelve changes. Jigs are seen fitted to these tables to grip axle boxes in parallel and angular positions.

The combination of boring, facing, drilling, and milling in one machine is well illustrated in the series of that type built by Messrs. George Richards & Co., Ltd., of Broadheath, near Manchester (Figs. 3 and 4). They are manufactured in sizes to face up to 72 inches in diameter, and are capable of dealing with high-speed work.

The design, Figs. 5 to 7, is slightly suggestive of the horizontal boring machine, in so much as it includes a bed with a worktable, a boring head and a boring stay. But beyond these the machines involve radical departures from the standard type. The principal elements are the facing head, and the tables with their essential mechanisms. The facing head with its spindle is carried on a frame which slides on an upright that is bolted to the bed. The sliding frame is guided on one member only of the upright,—the narrow guide now so common, and is locked at any height by two bolts. The spindle runs in phosphor bronze bearings and carries the facing head, the movements of which are changed through gears, direct for heavy work, and through auxiliary gears for rapid light work. Forty-eight speeds in all are obtainable. Changes between slow and fast gears are made by a crank handle at the front of the spindle frame. The slide which carries the facing tool is actuated by a screw. The feed to the slide is continuous in either direction, inwards for roughing, outward for finishing, changed by the movement of a lever without stopping the machine. In the event of the slide being permitted to over-run, a frictional slipping device prevents fracture of the gears. The facing head can be removed to

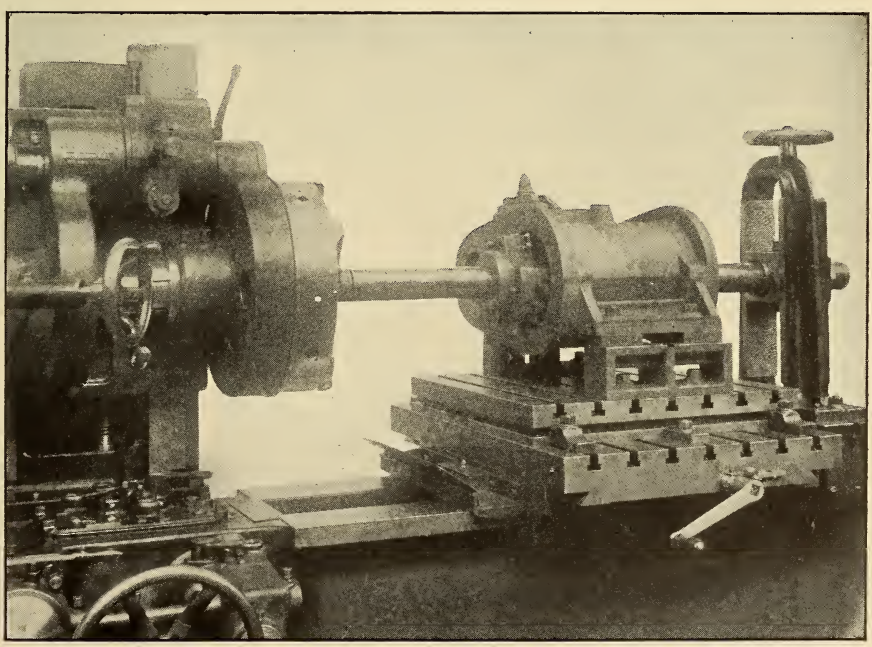


FIG. 4.—OPERATION OF BORING ON THE RICHARDS MACHINE

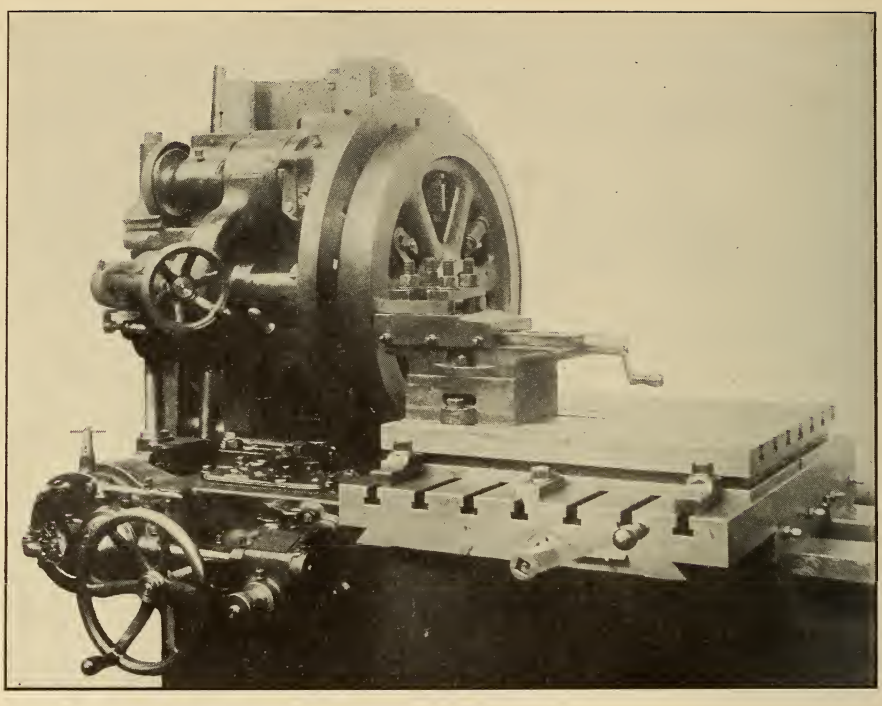


FIG. 5.—OPERATION OF TURNING ON RICHARDS MACHINE

permit of the substitution of heavy boring bar sockets, and large milling heads. The feed changes both to the spindle slide and the table are transmitted through gears enclosed in a box in oil, and changed through levers. By means of these, and an auxiliary feed box, a range of eight feeds can be transmitted to either the slow or the fast spindle speed ranges. Also, sixteen changes of feed to the spindle frame in the vertical direction, either upwards or downwards. The same number of changes of feed, sixteen, is transmitted to the table in the longitudinal and the transverse directions. The auxiliary feed box has a spring slipping device to prevent fracture of the gears, if the table should be stopped by a solid obstruction. All the levers for operating these motions are on top of the bed just below the spindle slide. The table slide which moves on the bed carries a table having slideways at right angles to the bed, with tee slots in its upper surface for the attachment of work. On top of this table a square rotating table is fitted, to be used when holes or faces at right angles have to be tooled, with provision for accurate locking. Though these machines are built to be belt driven from a countershaft, a motor drive can be substituted, using a variable speed motor, or a constant speed motor, or a single pulley drive, with corresponding alterations in the speed gear boxes.

Fig. 6 is a familiar machine tool which performs drilling, milling, boring, and surfacing operations, the Pearns patent as built by H. W. Pearns & Co., Ltd., of Broadheath. The tool equipment includes twist drills, reamers, snout boring tools, milling cutters of edge and face types, solid or with inserted teeth, and boring bars. Work is attached directly to the worktable, or jibs are readily made to suit different jobs, and fastened to the worktable. A slide rest can also be bolted down to

it to turn pieces put on the face-plate. Pipes, bends, and heavy cock and valve work are tooled accurately on different faces. All these things cannot be illustrated here but they will be understood.

For a machine of many combinations the Drummond-Barreto universal design cannot be eclipsed. It was designed by Mr. Arthur Drummond

Considering it first as a lathe, the centres are movable, ranging from 7 inches to 18 inches in height, giving a maximum of 36 inches in diameter or swing for turning. This range of centres is the equivalent of the range of movement provided in milling machine heads of the Lincoln type. The exact vertical alignment of the spindle head and the tailstock

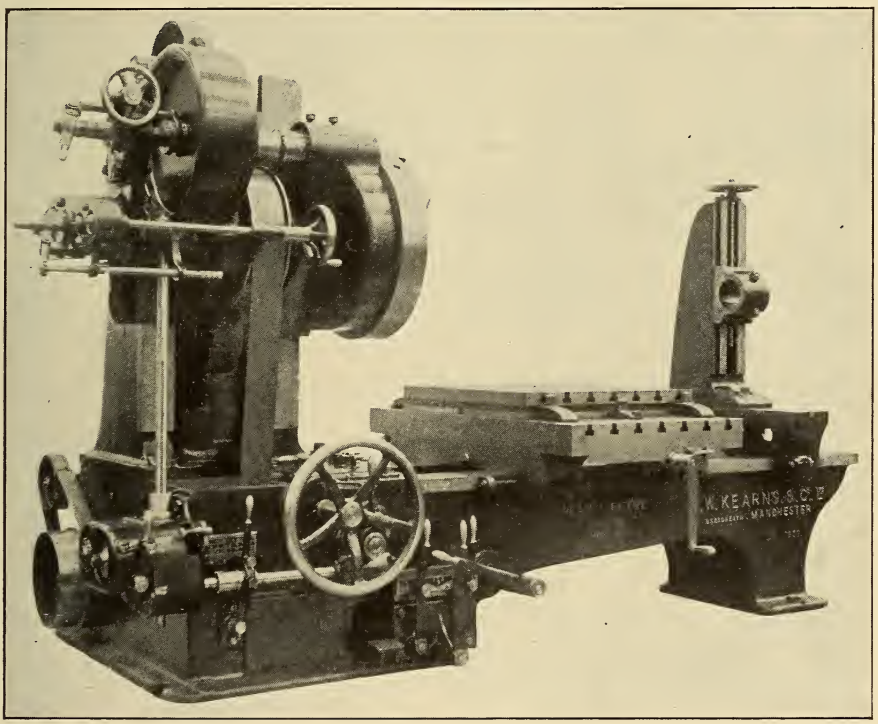


FIG. 6.—PATENT SURFACING, BORING, MILLING AND DRILLING MACHINE. H. W. KEARNS & CO., LTD., BROADHEATH, NEAR MANCHESTER

for the Baron Barreto for repair work on his yacht, and is constructed by Messrs. Drummond Brothers, Ltd., of Ryde's Hill, North Guildford. It will turn, bore, drill, mill and cut threads, and toothed gears, reminding one of the functions fulfilled by some of the older lathes. The design, however, is entirely original. It is suggestive of a cross between a heavy Lincoln miller and a lathe of modern type. The machine is shown by the photograph, Fig. 7, and by the drawings, Figs. 8 to 10.

at different heights is provided for by means of turned gauge rods of various lengths. The machine is driven from a three-stepped cone. Through this and gears and back gear twelve speeds are obtained in nearly geometrical ratio. Three are given by the direct belt drive, three more through the belt, and two direct gears to the spindle, and six are through this drive and the back gear. The spindle is relieved of torsional strain by adopting the method of the face lathes—the back gear pinion en-

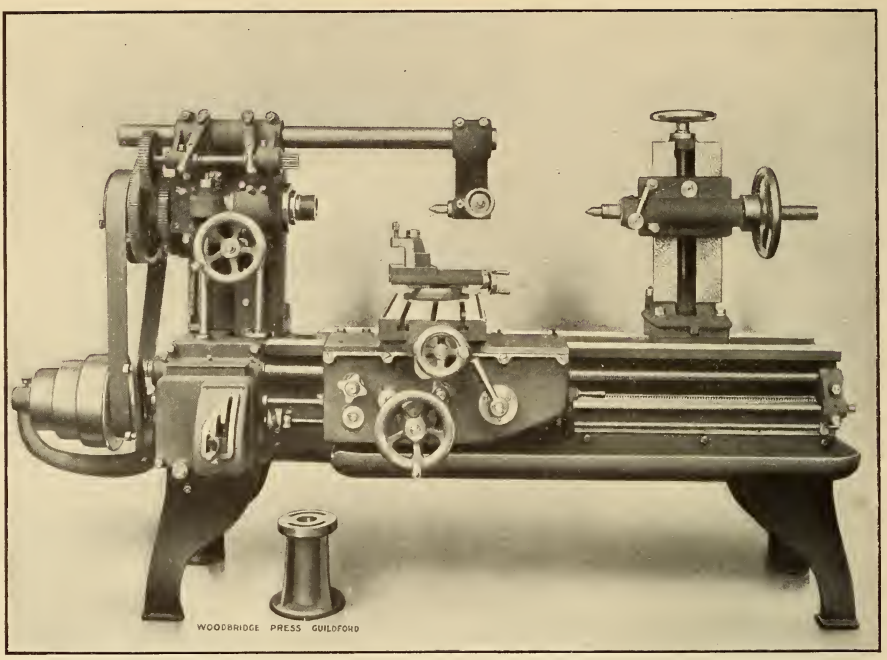


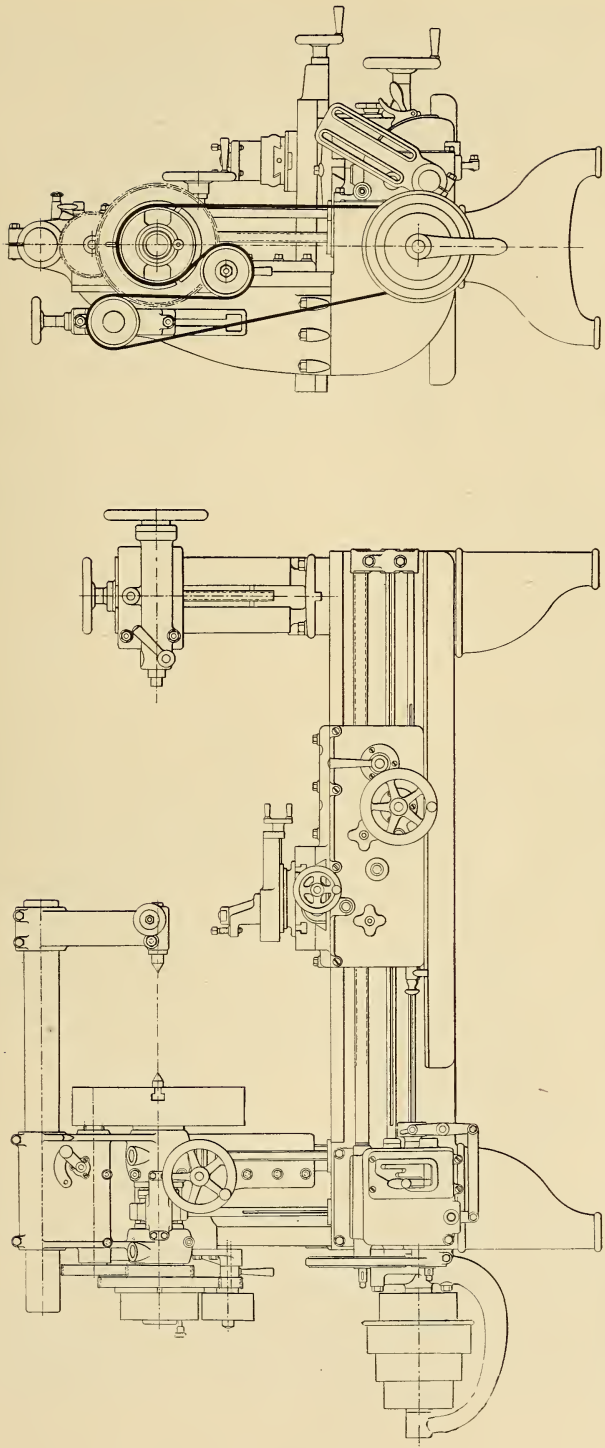
FIG. 7.—DRUMMOND-BARRETO UNIVERSAL MACHINE. MESSRS. DRUMMOND BROS., LTD., GUILDFORD

gaging directly with a gear on the face plate instead of in one on the mandrel.

Boring is done with the work attached to a tee-slotted table on the saddle of the slide rest, which has a self-acting traverse, with a range of three feeds up and down the bed. These are obtained from the feed rod through gears in the box seen in front of the bed to the left, and are available for surfacing. A lead screw and the usual set of twenty-two wheels provide for screw cutting. To provide for variations in height of centres the tool rest has two bases, one higher than the other for use when turning the larger diameters.

Milling cutters are supported between the mandrel and the centre which is carried by the sliding bar on the left-hand head. The work to be milled or the gears to be cut are carried on the spindle of a universal dividing head, or between the head and a tailstock, both of which are attached to the table of a saddle. The tailstock is used for spur gears for which the axis is parallel, the capacity in this case being for gears up to 14 inches in diameter. For bevel gears and tapered cutters the dividing head can be swiveled through 360 degrees being graduated suitably. Pitching is by holes in the dividing head, for which two index plates are provided, drilled with eight rows of holes each. By means of these, divisions can be made from 1 to 50, rising by 1, and all numbers divisible by 2 or 5 up to 100, and most numbers divisible by 4 or 5 up to 200, from 200 to 300 and some higher ones. If the dividing head is set with the spindle vertically, gears can be cut up to 40 inches in diameter.

A machine which combines radial drilling and end milling is built by C. H. Caton & Co., Ltd., of Keighley. Six radial drilling arms, each on its own independent pillar, are spaced equally on, and bolted against a long bed. Two milling heads can be slid along the bed and



FIGS. 8 AND 9.—FRONT ELEVATION AND GENERAL ARRANGEMENT OF THE DRUMMOND-BARRETO UNIVERSAL MACHINE. DRUMMOND BROS., LTD., RYDE'S HILL, GUILDFORD

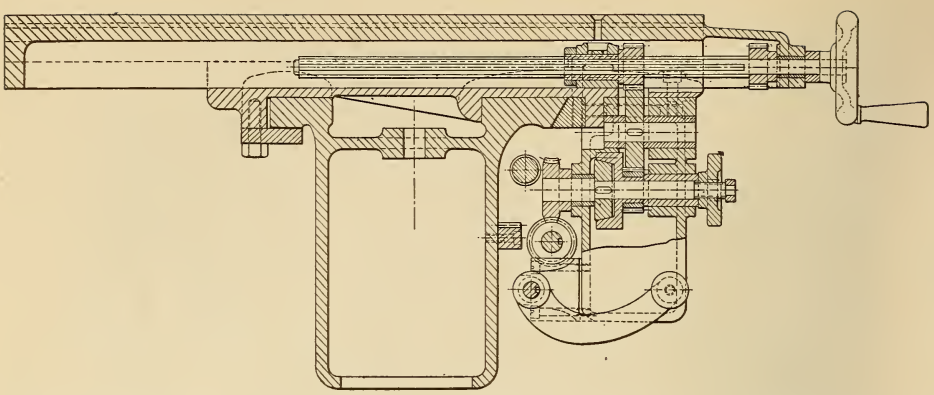


FIG. 10.—SECTION THROUGH BED AND SADDLE OF DRUMMOND-BARRETO UNIVERSAL MACHINE. DRUMMOND BROS., LTD., RYDE'S HILL. GUILDFORD

used at any position on it. One motor drives all the drilling spindles, another the milling cutters. Belt drive can be fitted if desired. The utility of such a machine lies in the railway and wagon shops in tooling railway carriage sole bars, headstocks, diagonals, etc. The capacity of the machine ranges up to a length of 32 feet. The maximum radius of each drilling spindle is 4 feet, their maximum feed 12 inches, at three rates, maximum height above the work vices 14 inches. A channel 12 inches wide can be operated on. The machine weighs 24 tons.

Another interesting combination of allied functions is that of a massive boring mill, with a vertical cylinder boring bar, see Fig. 11, built by Ernst Schiess Werkzeugmaschinenfabrik. A. G., of Dusseldorf, for turbine cylinders. The boring bar is 18 inches in diameter. It carries the large tool holder adjustable vertically by means of two screw spindles. A novel feature of this holder is that it is counterweighted, cords passing from eyebolts on opposite sides of the holder and thence over three pulleys to weights at the rear of the machine. The tool bars on the cross slide are also counterweighted neatly with ring weights. These bars can be angled through 45 degrees. They have self-acting horizontal, vertical, and angular feeds. The cross-slide has power adjustments on the uprights. The machine is of immense proportions, weighing 240,000 kilogrammes, say 237 tons, and taking an electric motor of 75 horse-power to drive it. Platforms are provided for the operator on the tool holders and at the ends of the cross-slide.

In Fig. 12 is shown a newly designed vertical turning and boring mill with a turret head, and with two compound slide rests carried on standards flanking the worktable, so making a very complete machine. These tool rests have self-acting and vertical feed motions driven by gearing from the main driving shaft. Feeds are reversible, and are thrown in and out by clutches. The turret carries four tools, has a vertical self-acting feed, and a self-acting horizontal traverse along the cross-slide. There are three feed variations, and no two motions can be in action at the same time. All the self-acting motions are driven through one gear box placed on the base of the machine. This is by Messrs. G. Wilkinson & Sons of Keighley.

So many tooling operations have to be performed on faces which stand at right angles to each other that provisions for this are included in very many machine tools, besides the boring and surfacing machines

already alluded to. A fair number of the pillar and knee design of milling machines have arrangements for performing both offices, either by the swivelling of a single spindle, or by the utilisation of two distinct spindles. The plano-milling machine is frequently provided with one or with two horizontal spindles in addition to those which lie in the vertical direction. This design follows that of the planing machine fitted with side tool boxes. In some shapes the table is made to swivel in order to present faces at right or at other angles to the tool. The same design occurs in some drilling machines. In many radial machines the drill spindle can be sloped away from the vertical for angular drilling. This is an alternative to tilting tables, and is not quite so satisfactory.

Even some highly specialised machines are combination machines. Notably the universal gear cutters, the hobbing machines designed to cut spur, spiral, and worm gears, the universal grinders, and the turret lathes. Each is developed on an underlying principle to perform just one class or group of manufactures, yet each is varied to enable it to handle every variety included in that class.

Related, though varied operations are performed on turret lathes in order to avoid dividing the work between more than one machine tool, which would be ruinously expensive now in the class of work done on those lathes, though it had to be done formerly. The operations performed are turning, straight and tapered, and roughing and finishing, boring, drilling, facing, forming, screwing and tapping, knurling, and cutting off. All are often done without intervention, and without after gauging and correction. Two opera-

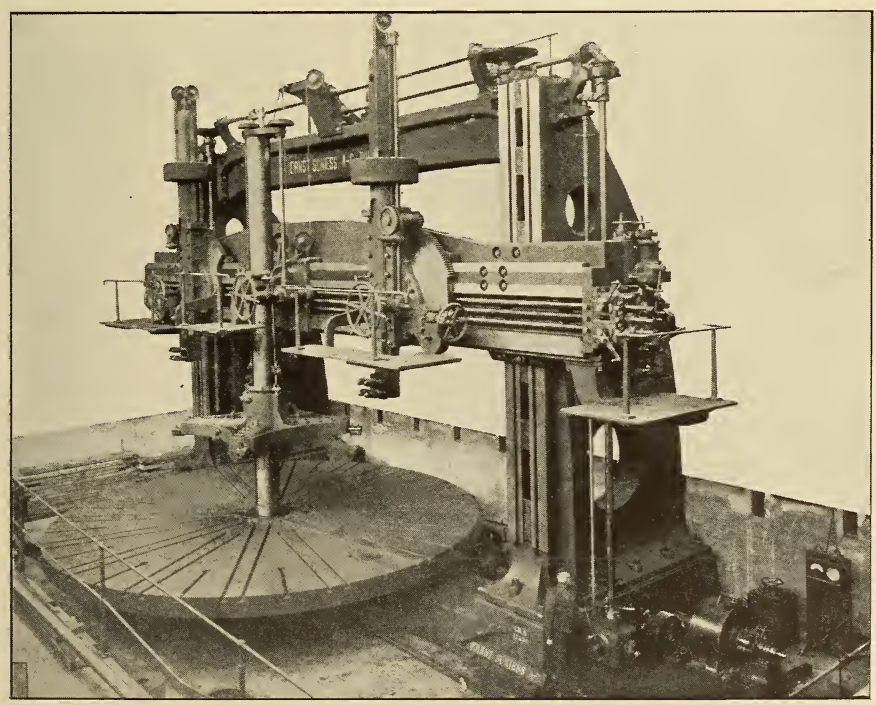


FIG. 11.—VERTICAL TURNING AND BORING MILL FOR TURBINE CYLINDERS. ERNST SCHIESS WERKZEUGMASCHINENFABRIK AKTIENGESSELLSCHAFT, DUSSELDORF

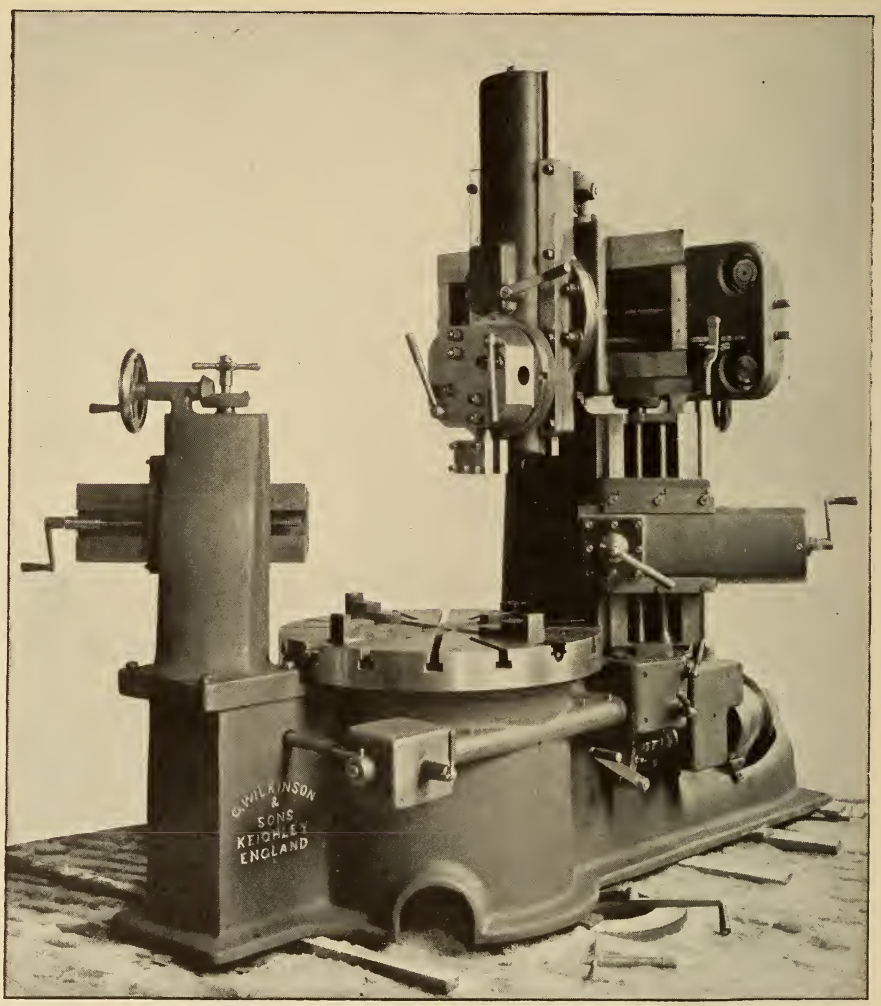


FIG. 12.—HIGH-SPEED VERTICAL TURNING AND BORING MILL, WITH TURRET HEAD AND SIDE TOOL. G. WILKINSON & SONS, KEIGHLEY, ENGLAND

tions only are excluded, gear cutting, and grinding, though the turning of gear blanks is a common operation.

A design along which developments have been proceeding slowly for some years past, following the early Swedish patents, is that of combining several spindles in a turret which rotates in a horizontal axis. Such a machine, for which Messrs. C. W. Burton Griffiths & Co., of Ludgate Hill, are the agents, is shown in Figs. 13 to 15. It is a semi-automatic chucking machine having a rotary work holder, articles held in which are presented successively to fixed tool spindles which turn, bore, face, and thread. There are two tool spindles in front and two in the rear, rotating in two heads which flank the rotating chuck, and the simultaneous operation of each balances the thrusts on opposite sides of the chuck. The advantage of locating the tool spindles in pairs in front and rear is that tools can be arranged and set at the front during the time those in the rear are operating, so that there is no stoppage of the work while pieces are

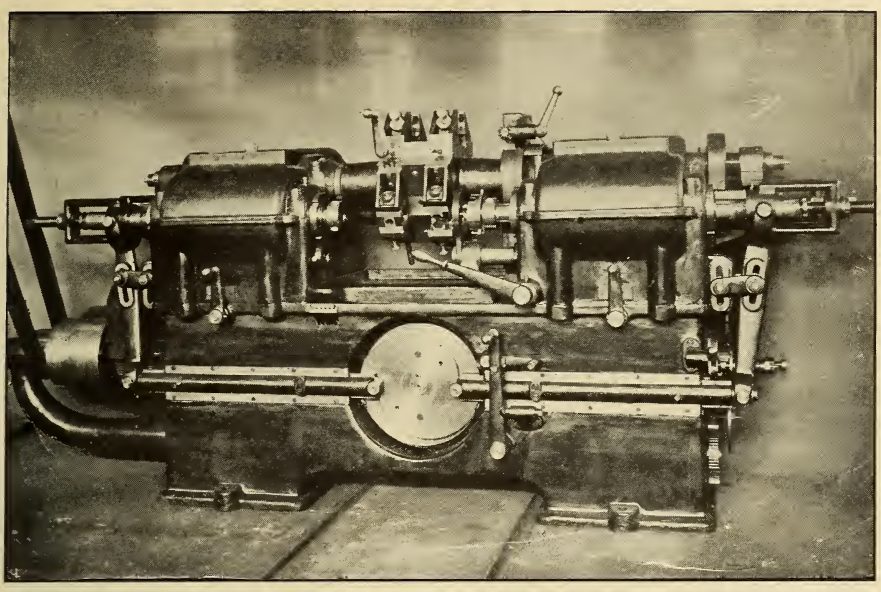


FIG. 13.—FOUR-SPINDLE, SEMI-AUTOMATIC CHUCKING MACHINE. C. W. BURTON GRIFFITHS & CO., LUDGATE SQUARE, LUDGATE HILL, LONDON, E. C.

being put in and taken out, or while tools are being changed. Another feature is that the cams by which the spindles are fed are carried on the front of the machine, where they can be changed quickly. With the exception of the insertion and removal of the work and fixing up of the tools, the movements of the machine are automatic. The spindles rotate simultaneously and continuously.

Though the machine fulfils several functions it is designed especially for dealing with cock and valve work.

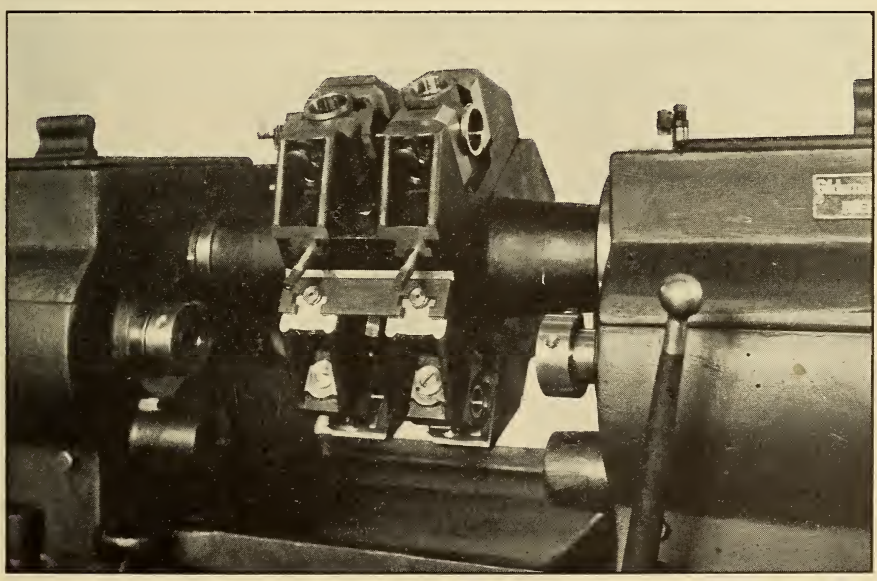


FIG. 14.—DOUBLE WORK HOLDER OF MACHINE. C. W. BURTON GRIFFITHS & CO.

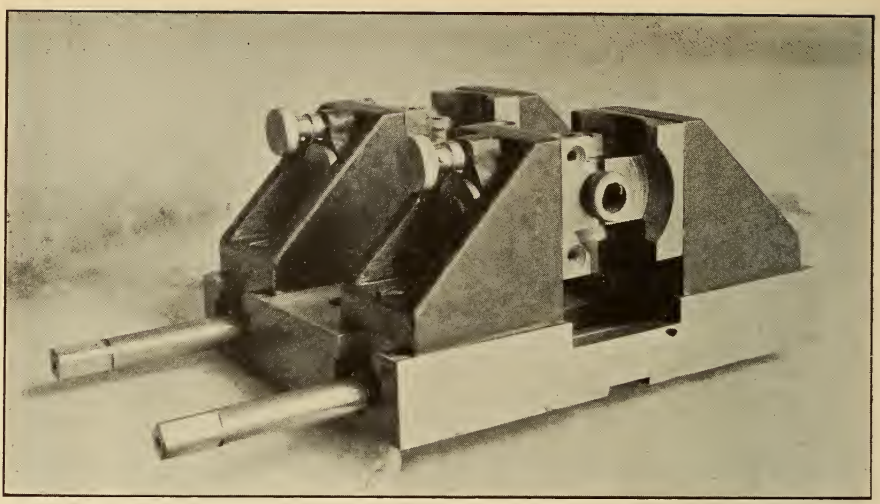


FIG. 15.—SCREW VISES AND FALSE JAWS FOR HOLDING WORK

The special fittings are comprised in the work holders or chucks, which are fitted either with screw vises and false jaws for gripping screwed valve bodies, Fig. 15, or with screws, clamps, and plates, for holding flanged bodies. Plugs, nipples, glands, and minor fittings are also held in the vices, and the false jaws are made to suit the various forms of these pieces.

A combined disc grinder and emery wheel, by Charles Taylor, Ltd., of Birmingham, is shown in Fig. 16. It affords the abilities of two distinct machines in the space of one. Otherwise the machine is of the firm's standard design. A refinement is the movement of the top slides on ball races, which give an easy motion. The discs have a special groove cut in their faces. Water troughs are fitted to catch the dirt. Work is turned, bored, faced, and threaded. The boring and facing are usually done by the spindles at the front and that of tapping and threading by those at the back. The traverse of each spindle can be adjusted independently of that of the others.

The combination of allied though dissimilar operations has its utilities when the object is to avoid transport from one machine to another. An old familiar example is the union of punching and shearing, on double-ended machines generally, but in some cases on single-ended machines used for light work only. In this case the shear is above and the punch below.

A very fine specimen of a combined planing and milling machine designed for tooling turbine cylinder

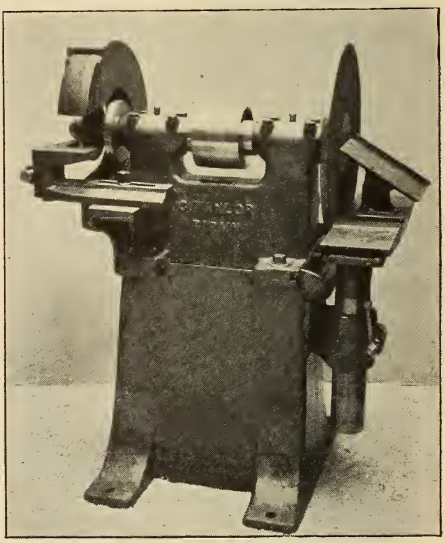


FIG. 16.—COMBINED EMERY WHEEL SEVEN-DISC GRINDER. CHAS. TAYLOR, LTD., BIRMINGHAM

sections is shown in Fig. 17 by Ernst Schiess. The cross-slide, which is of unusual length, extending far beyond each housing, carries two planing tool heads and two milling heads. There is in addition one planing head on the right-standard. The enormous dimensions of the machine may be inferred from the fact that it weighs 165,000 kilogrammes, or 162 tons, and is driven by a 50 horse-power electric motor. The table is 10 feet 10 inches wide, runs on three flat ways, and is driven by two racks and pinions. The capacity of the machine covers a length of 32 feet 10 inches, a width of 13 feet 11 inches, and a depth of 9 feet 10 inches.

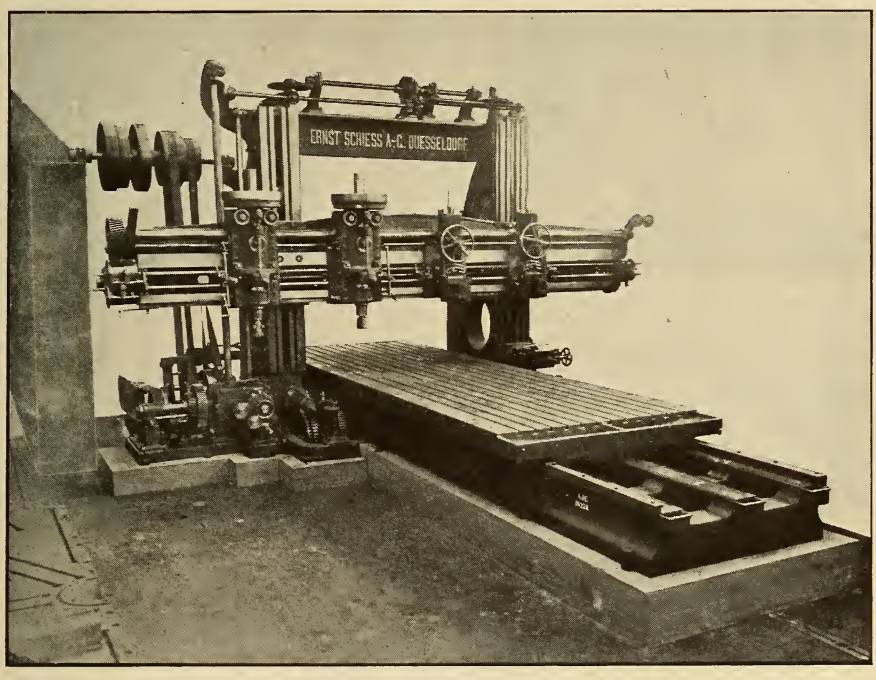


FIG. 17.—COMBINED PLANING AND MILLING MACHINE FOR WORK ON TURBINE CYLINDER SECTIONS. ERNST SCHIESS WERKZEUGMASCHINENFABRIK A. G., DUSSELDORF

Two useful dissimilar combinations are built by C. H. Caton & Company, Ltd., of Keighley. The first is a vertical turning and boring mill with a slotting attachment. The second is a slotting machine with which milling is combined. The utilities are obvious. In the first, key grooves can be slotted after wheels have been bored and turned. In the second, the valve seats and chests on locomotive cylinders can be tooled. The Whitworth motion is used in each for driving the rams. The two mechanisms cannot be put into action at the same time. In the second machine the milling spindle is enclosed in the slotting ram, passing through it, and being driven by helical gearing. It has four speeds and eight feeds.

Our last example is that of an attachment to a machine. It is one for castellating hexagon nuts for use on the Brown & Sharpe No. 2 automatic screw machine, after they have been cut from bar on the machine. The views, Figs. 18 and 19, give front and back views of it. It consists of a set of three saws for slotting the nuts, an indexing mechanism for locating the nuts in

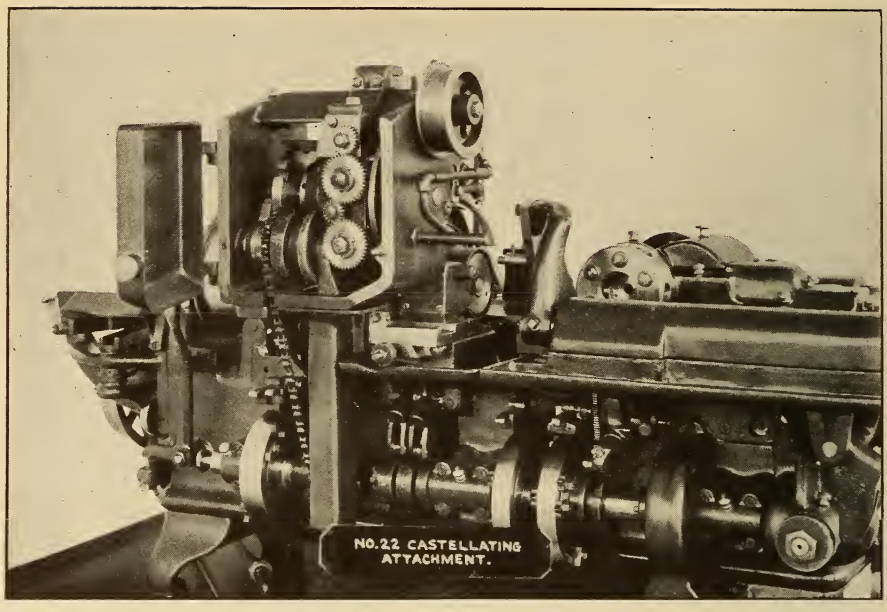


FIG. 18.—NUT CASTELLATING ATTACHMENT TO AUTOMATIC SCREW MACHINE. BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

the proper positions for slotting, a feeding mechanism for the cutters, and a swinging arm for transferring the nut blanks from the bar to the attachment. The saws are driven by a belt from overhead, but the rest of the mechanism is driven from the cam shaft of the machine. The nuts are inserted in bushings, of which there are six, in a magazine plate on

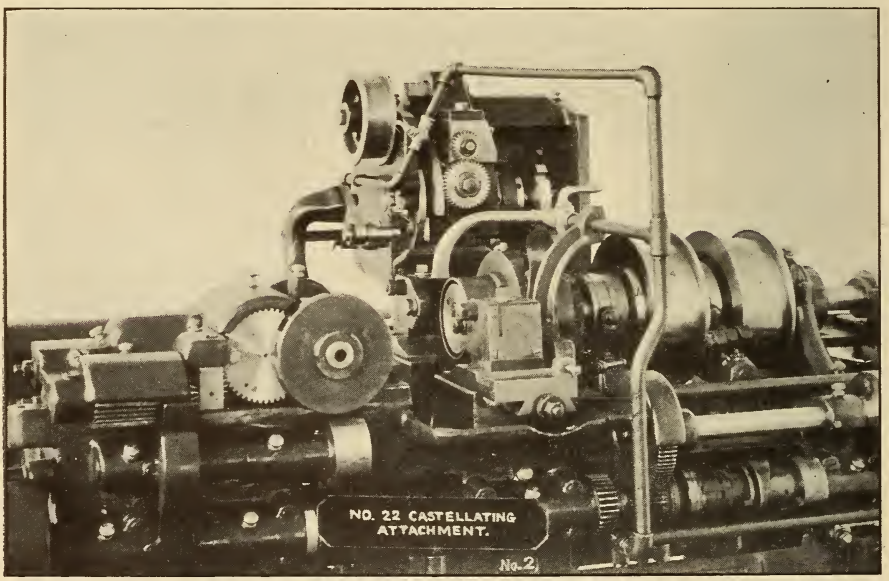


FIG. 19.—NUT CASTELLATING ATTACHMENT TO AUTOMATIC SCREW MACHINE (REAR VIEW). BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

a sleeve on the main spindle of the attachment. As many as a thousand nuts a day have been produced on this machine. The saws have run ten days without regrinding.

As the dimensions of machine tools grow, so often does the desirability of including combinations become more cogent in order to avoid resetting on other machines. But the difficulties in doing so increase with dimensions. What is feasible in a turret lathe or a grinder becomes impracticable in very massive tools. And here the opportunity and rivalry of the portable machine tools come in. It is easier to bring these tools to the work than to manipulate the massive castings and forgings on or between very heavy machines. This explains the multiplication of the small specialised tools for planing and shaping, key seating, drilling, facing, and tapping, a movement which has been so greatly facilitated by the advent of the electric motor and conductor. An adjunct to these tools, again, is the floor plate on which massive work is laid or bolted while the tools are attached to the plate located around the work where required, a device which is often more desirable than bolting the tools directly to any portion of the work itself.

The choice of combination machines in preference to those of a special character being largely governed by the volume of work of a given class required in any shop, it may often happen that a shop of large extent may find it necessary to use machines of this class. In these it may be the case that operations of some kinds are infrequent, and it is a canon that machinery should not be allowed to lie idle for any considerable proportion of the time. Some machines are very costly, so costly that nothing but a large volume of suitable work, sufficient to keep them constantly or almost constantly employed, would warrant their purchase. Occasional jobs would be more cheaply tooled by a makeshift rig-up on an existing machine, or by putting them out to firms suitably equipped for their performance. Thus, though combination machines are not regarded with much favour in large modern factories, because the tendency is always in the direction of division of tasks, yet there are advantages in their use. Everything depends upon the class of work done in a shop.

MAKING THE PUBLIC WORK

By Reginald Pelham Bolton

THE developments of mechanical invention have generally taken the form of relief of human physical labour. The economic value of machinery is really based upon its substitution for one or other form of effort, and in the early days of the past century it was common to base the value and effect of mechanical appliances and methods upon comparisons with the product of muscular exertions.

It was thus natural that at an early date in the age of machinery the determination should be made of the mechanical equivalents of human energy in various forms, most of which have been, to a great extent, superseded by mechanical contrivances at the present period.

All forms of manual labour have been largely discounted by machinery, and much of the energy involved in horizontal and vertical transit has been reduced by the railway and the elevator. But there still remains an almost universal demand, upon humanity of every age and class, for exertion in the form of walking and in ascending hills or slopes, and the interior spaces of buildings still require of the majority of persons some labour in ascending and descending stairways.

The convenience to which most metropolitan residents are accustomed in the use of elevators has educated the majority to avoid the use of stairways, and one of the elements in the prevailing preference for apartment life has been its relief from the necessary ascent of domestic stairways.

The invention and introduction of a moving stairway was a natural outcome of this educative process, and in the form of the "escalator" it is now recognized not only as a means of relief from labour, but as a successful rival of the elevator in many positions where the latter appliance has heretofore been considered the only practicable means of vertical locomotion. For certain positions and conditions, particularly those in which very large numbers of persons congregate and desire to advance in a single direction, the capacity of the modern escalator is now established as far exceeding that of elevators in any reasonable application.

It is scarcely necessary to point out in such a connection the advantage that ready and convenient means of access to the upper portions of buildings brings to its owners. In these days it is generally recognized that such conveniences should not be merely sufficient, but should be convenient and rapid in character, and should afford to those persons who do not possess the fullest vigor and physical strength all possible assistance and alleviation of the labour of ascent and descent.

The physical labour involved in ascending and descending flights of stairs and steps has at all times practically limited the height of buildings. The labour of the ascent was long ago established comparatively as being about eighteen times that of movement along the level space of equal distance within the same period of time. So long, therefore, as steps or stairways alone had to be depended upon for access to upper floors, it was inevitable that their height should be limited to that which did not require an exhausting

exertion on the part of the tenant or visitor in reaching the upper stories of a building.

It is not necessary to look back in the history of such a city as New York, for example, for more than a third of a century to realize that this was the prevailing condition which, up to that time, had limited the height of buildings to a level of five stories. Very few buildings, and those only of a special character, exceeded this height up to the introduction of the elevator, and modern developments in the art of building have centered about the mechanical appliances which have been developed to overcome the difficulty of intense human labour in access to their upper floors.

The prominent forms of elevators are to-day standardized and recognized as practical contributions to commercial efficiency of many buildings and industries. Their field of operation has widened as each successive development of speed and security has demonstrated their capacity to serve the public convenience. So much has this convenience contributed to commercial results, and so great have been the advantages to the value of property by mechanical conveniences of this nature, that structures of heights even less than those which our predecessors were willing to ascend by their own efforts are now provided with means of ascent and descent by elevators.

In structures devoted to public or semi-public purposes, such as city buildings and railroad terminals, public convenience is of equal moment, as well as a source of pecuniary advantage, and some means of alleviating the labour of transit across such structures as a bridge or from one level to another in a railroad station, or some means of ascending to the upper stories of public buildings, has come to be regarded as a modern requirement. The need has been met by the introduction of the moving stairway, which serves the general convenience not only of active and energetic persons, but that of the young and old, of the weak and infirm alike.

The rudimentary method of ascent and descent of moderate heights was by the use of a sloping path or inclined plane. It was utilized, with vast expenditure of human energy, in the construction of the Pyramids, and was probably one of the very first steps in the development of the mechanical arts. When the inclined plane became too steep for the safe transportation of men and materials the use of cleats or rudimentary steps may have led to the step-ladder, and long centuries of further developments may have been required for the development therefrom of the stairway.

Where large numbers of persons are compelled to pass and repass, the elementary "ramp" offers some advantages, as regards safety and simplicity, over a stairway. The stairway is peculiarly dangerous to human life and limb under crowded conditions, and the effort required in ascent brings about a pronounced check in the movement of large bodies of persons in motion, which has been assumed to be absent from the ramp. A return has, therefore, been made to the inclined plane, or "ramp," as the means of access to or egress from several modern railroad stations, the depth of which below the general surface has been too great for convenient stairways and yet too small to develop the advantages of elevators.

The traveling public, brought to and landed at low levels in these stations, is confronted by exits extending upwards upon the ancient method of the inclined plane, involving physical effort and personal fatigue in the ascent to the level of the streets.

The descent of the same form of planes is also accompanied by some fatigue accompanying the motion of descending angular inclines. For such conditions the moving stairway appears to afford advantageous relief, both as regards the convenience

of the passengers and the removal of congestion. The capacity of an escalator in the movement of people is very considerable. Such an appliance having a width of only 40 inches will carry upwards of 10,000 persons per hour.

The use of this apparatus, while it may not be a direct means of income or profit, has been found advantageous merely by the relief afforded to patrons of railroads and of large stores and the advantage which it affords to its owners in the avoidance of congestion, delay and accident. The general public is becoming habituated to its use and to the relief it offers, and this appreciation will certainly be followed by a demand for its application to many other situations where people in large numbers are compelled to ascend or descend from one level to another. Such a demand soon becomes irresistible, by reason of the patronage of the general public following superior conveniences, just as has been the case in buildings where the developments of elevator service have made possible structures of great height and expense of construction.

Some persons have expressed the view that the amount of effort required to climb a stairway or ascend a modern incline is not of sufficient extent to warrant consideration of relief by devices of an expensive character such as the escalator. Such a generalization is probably due to lack of definite information upon the extent of effort thus required.

An excellent opportunity was recently afforded to secure some comparative observations upon this subject—upon the "ramp" or incline recently constructed as a part of the future exits from the new Grand Central terminal at Forty-second street, in New York City. The facilities for observation of individual and combined movement in a place of such large usage were almost unlimited. This ramp is 231 feet long, having a break or flat section near the middle of its length, which is 13 feet 9 inches in length, thus forming two inclined parts of slightly differing grades—one of 115 feet long, which has a rise of 12 feet, and a second part 116 feet long, having an elevation of 13 feet.

The ramp, by reason of its location with a level space at foot and at the summit, has afforded an opportunity of ascertaining the actual effect upon passengers of all ages and conditions of the labour of ascent, and a very careful study, comprising a large number of personal observations, was recently made, in order to determine these effects.

Observations were first taken upon the speed of different classes of pedestrians walking along the street at the early part of the day, when they would naturally be free from fatigue, and the movement of groups of persons, as well as individuals, was timed, with stop-watches, while passing across a distance of 100 feet along the sidewalk. These were followed by similar observations taken upon the crowds and individuals, approaching the lower part of the ramp and upon its lower and upper sections, and thereafter along the level at its summit.

The first observations established very decided differences between the movement of the various classes of people observed across the measured space along the level sidewalk. Men evidently hastening with effort occupied a minimum period of 14 seconds, while men walking in an ordinary manner occupied 19 seconds over the same distance. The time required by women under similarly varying circumstances was from 20 to 22 seconds. Groups of persons always moved at the slowest rate. Observations were then taken to determine the time required to pass over an equivalent distance of level surface extending from the summit of the ramp. The rate of motion of persons having thus ascended the ramps was evidently lessened, for it was observed that men hurrying oc-

cupied from 17 to 21 seconds over an equal space, and women not less than 24 seconds. Groups of persons close together required for the same space 25 seconds. All these indicated that some loss of speed had resulted in each class observed, due to the prior exertion of climbing the incline. Observations were then transferred to persons moving up the ramp or incline, and the time required to pass over an equal measured space upon the ramps was found to vary as follows:

	Seconds.
Men hastening, occupied	17 to 24
Women hastening, occupied	21 to 25
Two or more men together	23 to 27
Woman carrying package or child	28
Heavy and elderly men	30 to 38

These observations afforded comparative results of interest, and made it evident that there was considerable effect of delay, not only on individuals, but upon the whole movement of passengers, due to the inclines.

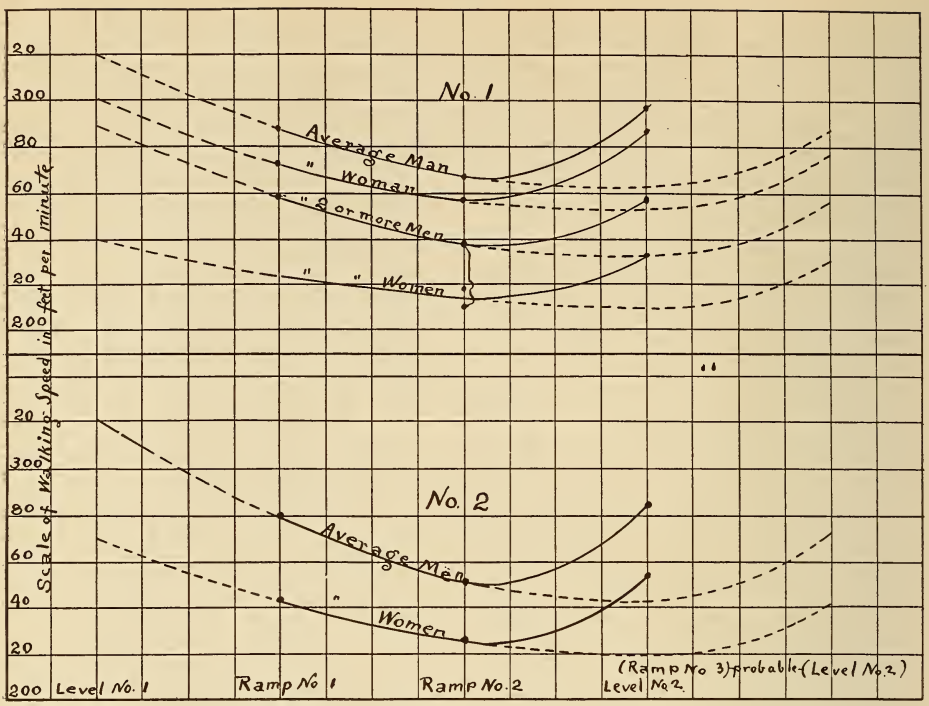
It also seemed probable that some general reduction in the walking speed of all persons at the top of the incline had resulted after they had passed up the grade, and this reduction in the normal walking speed could be compared with the speed prior to ascent and its effect established for some distance after passing the crest of the ramp.

A series of observations were, therefore, made by observers with stop-watches, following individuals or groups as they approached the foot of the ramp and passed up each of its two sections and then covered a certain distance beyond the crest of the ramp upon the level walk beyond.

The result of a large number of such observations were compared and plotted, and show that the normal walking speed of all classes of individuals and groups of persons was reduced upon the first part of the ramp, was still further reduced upon the second section of the ramp, and that over a space of 100 feet at the top the walking speed of the same person was in all cases reduced from the normal rate as observed on the level below the ramp. In other words, the effect of the ramp was not only to reduce the speed of the pedestrian upon the incline itself, but so to exhaust his, her or their physical energy as to result in their walking slower on the level at the top of the ramp than they had done on the level space at the foot of the ramp.

One very interesting observation was that of the crippled man, whose motions were watched with careful solicitude by the observer with stop-watch in hand. Anyone who has witnessed the motions of a person walking with a crutch must realize how extremely laborious is the process of swinging the crutch around upon an incline, striking that incline at a point above the normal level and hoisting the weight of the person over the angle of the crutch. His normal walking speed appears to have been about 60 per cent. of the average speed of men not incapacitated as he was, or about 190 feet per minute. Upon the first incline he walked at the reduced rate of 172 feet per minute, but upon the second ramp at only 122 feet a minute, or about 64 per cent. of normal; and it was noted that after climbing the ramp his speed on the level space beyond was but little above that which he had been able to maintain while climbing upon the first ramp, or about 80 per cent. of normal, indicating a temporary loss of energy of 20 per cent. of his walking power.

Another interesting condition was brought out by the observations—by comparison of the effort and speed of ascent by men with that of the weaker sex. It was evident that upon first striking the rising grade of the ramp a man would exert a greater degree of energy, which resulted in the maintenance of his normal walking speed for a short distance on the grade; but a gradual and increasing slackening of this speed resulted. A woman, on the contrary, on striking the foot of the grade slackened her speed almost



FIGS. 1 AND 2.—DIAGRAMS SHOWING RELATIVE SPEEDS OF PEDESTRIANS ON LEVELS AND ON RAMPS, FROM OBSERVATIONS TAKEN AT GRAND CENTRAL STATION, NEW YORK CITY

simultaneously, and on comparing the time occupied by persons of the two sexes up the first incline it became evident that the speed made by the weaker sex was the more uniform of the two.

In both, the falling off of speed was pronounced as the pedestrian approached the crest of the ramp, and in both, also, the falling off from the normal walking speed developed below the incline was very apparent after the ramp was ascended and while walking along the measured distance of 100 feet extending from the crest of the ramp towards the street.

These results have been plotted in diagrammatic form in two diagrams. In these diagrams the walking speed in feet per minute is shown on a vertical scale, and in the horizontal scale distances are plotted corresponding to the level space at the foot of the ramp, the first part of the ramp, the second part of the ramp and the level space at the top of the ramp. Dotted lines are extended, showing the progression of the loss of speed which would follow the introduction of a third ramp, which corresponds with the extension of the present ramp to the future lowest train level, and these are further extended to show the proportionate reduction in walking speed upon the level which would result from such an extension of the incline.

Diagram Fig. 1 shows the average speeds developed by all the observations, and from these it appears that the average normal speed of men walking from the train to the ramp is 320 feet per minute, which, upon the first ramp, falls to 279 feet a minute, or 87 per cent., and upon the second ramp to 249 feet a minute, or 78 per cent., and upon the third ramp—if such should be established—to 242 feet a minute, or 75½ per cent. The average speed upon

the level part above the two ramps was 283 feet, or a loss from the original or normal speed of 11 6/10 per cent. Should a third section of ramp be required to be ascended, the speed thereon would fall to 242 feet, or 75 per cent., of normal, and that upon the upper level to 271 feet, or a loss from the normal speed of 15 3/10 per cent.

The average normal speed of women upon the level of the lower platform is 270 feet a minute, which falls upon the first ramp to 240 feet, to 224 feet upon the second ramp, and would fall to 219 feet upon a third ramp, if provided. The corresponding speed upon the level at the summit is 251 feet per minute, or a loss from the normal speed of the subject of 7 per cent., or, with a third section of the ramp, this would be increased to 11 per cent. The loss of speed and of time is, therefore, relatively less with women than with men.

In Diagram, Fig. 2, plotted from another set of observations, these curves are repeated, with the addition of curves showing the speed of the movement of two or more men walking together and of two or more women walking together. In both the same general law is found to exist as previously described—namely, the men, walking normally faster than women, attack the incline with a greater degree of energy and relatively lose more in speed and time in their progress and thereafter than do the women, who proceed throughout at a more leisurely pace.

All of the information thus obtained has been averaged and plotted in a third diagram, Fig. 3, in which the curves of speed have been projected so as to show the walking speed of the subject if the ramps had not been encountered, and also upon the third section of the ramp which may be expected to be added in case the use of stairways is abandoned at the lowest level.

The observations further afford average data applicable to all classes of passengers of both sexes.

The normal walking speed upon the level of the lower platform is found to be 304 feet per minute, which conforms exactly to the conclusions in established works on physical subjects as being the average walking speed of civilized mankind. The effects of the effort put forth in ascending the incline are also determined by the observations.

The normal walking speed upon the first ramp falls to 267 feet per minute, an average loss of speed of 12 per cent.; that upon the second ramp to 245 feet per minute, a further reduction of 8¼ per cent. upon the speed on the first ramp and a ratio of 80 per cent. to the original speed, and that upon the third ramp to 238 feet per minute, or 78 per

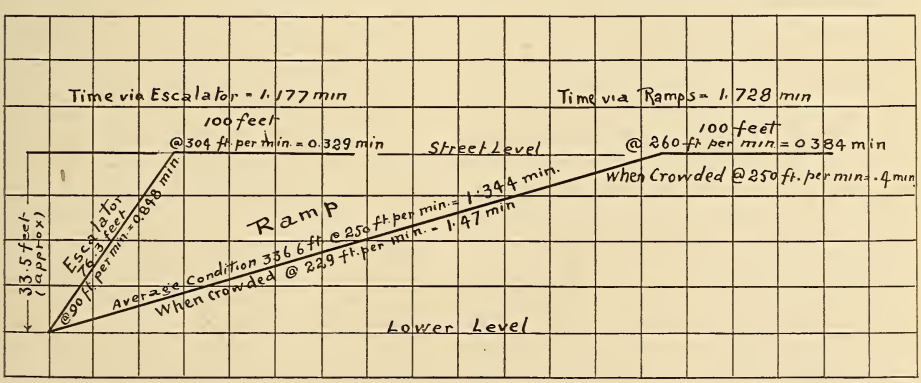

Time via Escalator = 1.177 min
100 feet
@ 304 ft. per min. = 0.329 min
Time via Ramps = 1.728 min
100 feet
@ 260 ft. per min. = 0.384 min
Street Level
When Crowded @ 250 ft. per min. = .4 min
Escalator
@ 90 ft. per min. = 0.848 min
Ramp
@ 250 ft. per min. = 1.394 min.
Average Condition 336 ft.
When crowded @ 229 ft. per min. = 1.47 min
33.5 feet (approx.)
Lower Level

FIG. 3.—DIAGRAM SHOWING RELATIVE SPEEDS OF PEDESTRIANS ON LEVELS AND ON RAMPS, FROM OBSERVATIONS TAKEN AT GRAND CENTRAL STATION, NEW YORK CITY

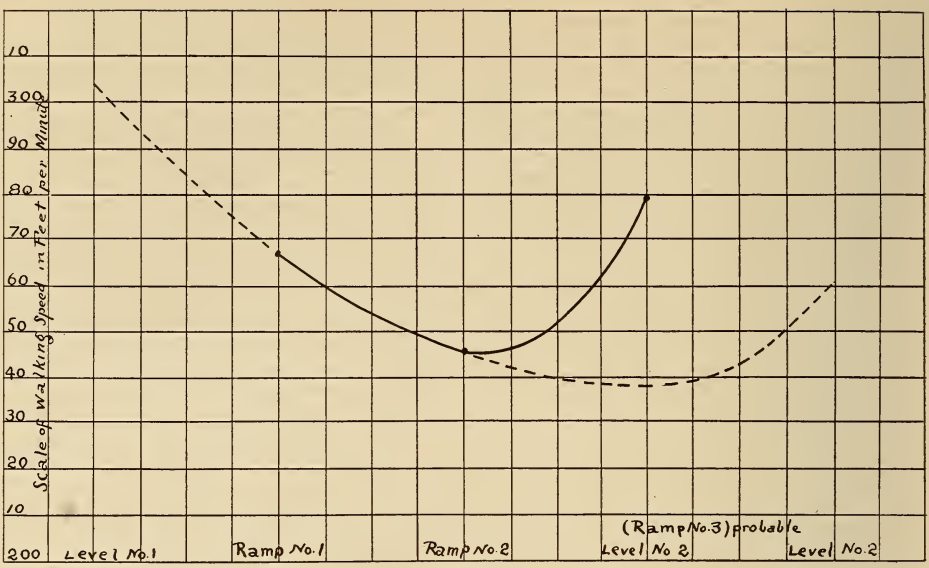


FIG. 4.—RAMP COMPARED WITH ESCALATOR

cent. of the original speed. The result of the work imposed by the ascent of ramps upon the average pedestrian is shown in the walking speed developed upon the first 100 feet beyond the summit of the ramps. This has fallen from the normal walking speed of 304 feet per minute to a speed of 260 feet per minute, being 85½ per cent. of the original and a loss of energy of 14½ per cent.

This represents in a very definite form the extent of the physical exertion to which pedestrians will be put in ascending such ramps or inclines. The time lost is shown in Diagram Fig. 4, in which the observed time occupied in ascending the ramp and in passing the one hundred feet beyond it is compared with that which would be occupied in entering a moving stairway or escalator, moving at the speed of 90 feet per minute, and in walking at normal speed 100 feet beyond its highest level.

By this comparison it is found that the actual loss of time due to the ramp is about one-half of a minute per person. The average time occupied in passing over the ramp is 1.34 minutes, and the average time occupied in passing 100 feet beyond the ramp is 0.38 minute, making a total of 1.72 minutes.

The period required for ascent of the difference in levels by means of an escalator would be 0.85 minute. The passage across the 100 feet at the crest, at normal speed, would then occupy 0.33 minute, or a total time of 1.18 minutes; therefore, there is a loss of time of each pedestrian who passes up the ramp of 32.4 seconds, or a little over one-half of a minute.

These interesting observations show how greatly the public is concerned in the provision of proper modern conveniences, both from the point of view of the saving of physical energy and the saving of time.

If the figures herein presented are multiplied by the vast numbers of persons who are using and are to use such great stations and buildings daily for many years to come, the wastage of human energy and the dissipation of human time become colossal in amount.

THE SHIPBUILDING INDUSTRY OF GERMANY

By Count Ernst von Reventlow

TO my English readers it will probably be no novelty when I state that German shipbuilding is of comparatively recent date; but, as an introduction, it is necessary to draw attention to this fact. The oldest German shipyard amongst those still existing and which are of importance is the Reiherstieg shipyard, in Hamburg. It has existed since the year 1706, but is an exception among German yards, as most of them are of much more recent date. This follows, naturally, from German history. After the liberation from Napoleonic rule a development in German shipbuilding began, especially at Hamburg and Bremen; but shipbuilding which had had considerable importance in previous centuries there and at Lübeck languished. English yards supplied Germany with ships, and this was the case long after the introduction of steam and the building of iron ships. Still, fifty to sixty years ago German shipbuilding, and the industries which are essential to the construction of a ship, began to develop. The "Zollverein" was created, and was of enormous utility in the economical development of Germany. Manufactories arose, and industry began to take the form which we now call "modern." Hitherto the German Federated States had had no warships, Prussia alone having a few small gunboats; but then came the year 1848, and with it the war with Denmark, at first carried on by Schleswig-Holstein, and later by the German Bund. This year was for German naval shipbuilding and the underlying idea, which has been called the "Fleet Question," of great and decisive moment. In this war Denmark blockaded the harbours of the German Bund, a fact which awakened a universal feeling of indignation and shame among the German States. In consequence, it was resolved in the Bunds Parliament to create a German fleet; but, as history shows, this did not, and could not, succeed, so long as the organization of the German Bund preserved so incohesive a character. There was no executive power, and, besides, it was impossible to collect the necessary money. At first comparatively large sums were obtained by voluntary subscription and collection, but as the earlier enthusiasm wore off it became more and more difficult to acquire funds. When the ships of the German Federation were sold, Prussia secured the best of them. Already, in 1848, Prussia had energetically began to build up her fleet, and followed up her plans in the subsequent decades with the well-known Prussian tenacity and consistency. The ships of the German Bund were almost all built in England and the United States, as also were those of the Prussian marine. It must be remembered that in the earlier decades Dantzig was the only Prussian naval harbour. Here, in the Klawittes shipyard, the first German warship, the corvette *Dantzig*, was built. Naturally, however, owing to inexperience in shipbuilding, whether in wood, or, later, in iron, up to the seventies a large part of the Prussian men-of-war, more particularly armoured, were obtained from English or French yards. In 1873 a new development began. The then chief of the Admiralty, General

von Stosch, ordered that all ships of the German Marine should be built in German shipyards, and, as far as possible, of German materials.

In the seventies several large private shipyards began to adapt themselves to the construction of large vessels of war; at the same time, following on the foundation of the German Empire, there arose a fresh impetus to German industry, trade and shipbuilding, and from this epoch begins a new era in the development of shipbuilding. This will be more clearly set forth later, when describing the individual shipyards. Of a truth, the great and rapid development which has gone on to the present day was as yet in its infancy. German shipowners could not be compelled, as was the navy, to build their ships in German yards. Even if they had so wished, the German shipyards were not in any degree in a position to meet the demands. In spite of this, it may be considered that shipowners were somewhat indifferent to the best interests of German shipbuilding; they were accustomed to obtain their ships from English yards; they had, justly, every confidence in the skill employed and in the construction of English ships, and they had every reason to suppose that even if the new German yards could produce the same quality the work could not be done so cheaply as in England. Rapidity of construction must also naturally be greater in English yards. It followed, therefore, that during the seventies the German transatlantic companies had all their large ships built in England, and, as a rule, only small ships could be constructed in the German yards. The position of German shipbuilding could not, therefore, be called prosperous. New yards, however, were created and older establishments enlarged. They hoped for and looked forward to the moment when better times would set in. No one doubted this, but year after year passed in waiting. Conditions were unfavorable. German industry had shown but a small degree of development, and much of the material for shipbuilding had to be obtained abroad. On their import there was a duty, and, therefore, the cost of ships was very much above that paid in England. These taxes on shipping material were abolished in the seventies. If this was of great advantage to shipbuilding, its later and more brilliant epoch began with the granting of State's subvention to steamers carrying mails. With his usual foresight, Prince Bismarck introduced this law into the Reichstag. By this law subventions were granted to mail ships, but the owners were obliged to have their vessels built in German shipyards. To this cause must be attributed the great development of the whole German merchant shipping. By the terms of this law mail steamers, as far as possible, had to be constructed exclusively from German material. This impetus, as in the case of the regulations of General von Stosch to the navy, proved of immense benefit. It was not, indeed, until the year 1886 that the construction of the first German mail steamers was commenced at the Vulcan yards, in Stettin. These were the steamships *Preussen, Stettin, Lubeck* and *Dantzig*. Previous to these ships only two large passenger steamers had been built in German shipyards, one in the Vulcan and the other in the Reihersteig, in Hamburg. The "North German Lloyd" had already existed for some years—namely, since 1857—and ten years earlier, in 1847, the Hamburg-American Line had been founded. Until the middle seventies this company had only had three small vessels built in Germany, the rest being constructed in England.

As regards subventions, it is well to note the following: Abroad, and especially in England, it has often been maintained, and is believed to some extent even to-day, that this satisfactory development of German shipping is due particularly to the

large subventions derived from the State—in fact, that it has only thereby been rendered possible. I have already said that these subventions were necessary, in the eighties, for the development of the Imperial Postal Service. This postal service was a new step, and the simultaneous demand by the Government that ships for this service should be built only in German yards, and, as much as possible, from German materials, brought about a very considerable increase in the cost of ships—necessary, if the yards were to be carried on without a loss. If we consider the subventions which the German Empire pays, they are not higher than those in other countries, but, as a matter of fact, much less. That is shown by the following table, which gives statistics for 1909:

	Mercantile Marine, Gross Reg. Tons.	Total of Subventions in Marks.	Pro. Per Ton.
Great Britain...	17,378,000	34,000,000	1.95
Germany	4,267,000	8,000,000	1.85
France	1,894,000	53,000,000	28.00
Italy	1,320,000	16,000,000	12.10
Japan	1,153,000	28,500,000	24.70
Russia	972,000	11,000,000	11.30
Austro-Hungary..	750,000	20,000,000	26.70
Spain	710,000	15,500,000	21.85

From this we see that the German subventions are not only absolutely, but proportionately, the lowest. They are slightly lower than those in England. In comparison, the English subventions seem astonishingly high, when we consider that the marine of Great Britain is so old and that she has practically a monopoly, not only of seaboard commerce, but of the world's shipbuilding. We must also bear in mind that German shipyards cannot be worked so cheaply as the English. When the celebrated Cunarders, the *Lusitania* and *Mauretania,* were about to be built the Cunard Line received a loan from the British Government of about fifty-two million marks, at 2¾ per cent. Here we have to deal with a very considerable subvention. The German subventions, on the other hand, are exclusively used for the postal service to East Africa, East Asia and Australia, and for postal service in East Asiatic waters.

The frequently recurring question as to whether German commercial shipbuilding cannot in the near future be carried out as cheaply as the English is, like all questions of the future, to be treated with discretion. In one respect British shipbuilding will always be in a more favourable position than the German—namely, in this, that Great Britain has at her command a larger number of efficient shipbuilding yards. She has never been placed in the position of having to refuse an order, either from home or abroad. It will never be the case—or at least that is my opinion—that Great Britain will have to refuse an order or not be in a position to carry it out in the short time demanded. In Germany, on the other hand, such a condition is conceivable. The possibilities of a change and an improvement in that direction would consist, not only in the growth of its own shipping, but also in an increasing regular demand on German yards through orders from abroad. These are all matters for the future. Germany may be satisfied that her shipbuilding industry has attained to a position which not only stands high but in many respects is at the head of international shipbuilding, and will remain so. For this reason I consider it regrettable, as is still the case, that German shipping companies as prosperous as the Hamburg-American Line have large ships built in England and not in Germany. These cases are exceptions, but it is to be hoped and expected that in a short time they will be things of the past. German shipbuilding has received great impetus from shipowners, notably from the North German Lloyd and the Hamburg-American Lines. The fast ship was an original idea which, even if there was a precedent in England, yet received its full development from these companies. What twenty-five years before had been considered a fast ship could no longer be so called, and we need not hold to figures to form a judgment.

The idea was to create a shipping line which should be, in every respect, suitable to the transatlantic passenger traffic. The success of the North German Lloyd in this respect is well known, but this could not have been the case if the shipbuilding industry, in particular the Stettin-"Vulcan," had not had the stimulus and been in a position to carry out the work in the most satisfactory manner.

The extraordinary attraction which fast steamers have had for the traveling public is due, not only to their rapid speed and the short time taken on the voyage, but also in a great measure to the perfection of their internal arrangements. The magnificence of decoration and the luxury of appointments, such as the North German Lloyd inaugurated in their ships, offered a strong contrast to their former simplicity. Looked at from an artistic point of view, these may be considered overdone, and, even from the practical standpoint, there is much that is superfluous. All this luxury has enormously increased the cost of such vessels, and their power to pay is, consequently, more difficult of attainment. To this must be added their double bottoms and watertight compartments. The "Vulcan" Company were also the first to call to their aid the highest artistic authorities, with a view to solving the problem of ornate and sumptuous internal decorations, which would act as an attraction to passengers and thus initiated a new epoch in ocean travel.

In the following decade fast steamers were still further developed, both as to size and speed, and there began that rivalry between the German and English steamers in which the German liners bore the palm until the arrival of the turbine steamers of the Cunard Line. The word "record" brings out the fact that the style of vessel in this sort of rivalry only depends to a small extent on the shipbuilding industry. Record-making proved a factor in the paying capacity of a vessel. It very soon became evident that there was a limit—namely, the coal consumption, which, as is well known, increases by leaps and bounds with every extra knot. The problem became more acute with every vessel, and it was a question whether the expenses of increased speed, notwithstanding the influx of passengers, were not heavier than the receipts could bear. For this reason shipowners have not attempted to compete with the records of the two subvention Cunarders. As to whether these pay or not, is a point which we will not discuss here.

German shipowners have lately gone on the principle of building vessels of great size, but only at such speed that the coal consumption and attendant expenditure will not absorb the returns. The forerunners of this type were the *Patricia* and *Palatia*. The great bulk of the traveling public prefer the ship which is suitable for passengers and freight, possesses moderate speed, and is comfortably furnished, being, at the same time, steady in the roughest seas. The first shipyard to build such vessels was the Reiherstieg, at Hamburg. The North German Lloyd adopted this type in the *Barbarossa,* and the latest leviathans are a development of this class of ship.

German naval shipbuilding suffered much from the fact that, up to the end of the nineties, the fleet was not only small but its future uncertain. It has been shown that in the eighties the powers of the torpedo boat were overestimated, and General von Caprivi and many other naval officers held the opinion that, sooner or later, the torpedo would supersede the battleship. In the previous decade there had also been a phenomenon which was prejudicial to the development of the navy, although this was not generally known. Public opinion in Germany had expected great things of the fleet of the North German Bund in the years 1870-71, although there were only three large armoured frigates, and two of these damaged.

This squadron lay in the Jade, as the naval authorities considered it useless to sacrifice it to the superior strength of the French fleet. On the conclusion of the war the opinion was almost universally held that Germany required but a very small fleet, with the result that building grew less and less. As has been mentioned elsewhere, the first armoured vessel to be constructed in a German yard was the *Preussen,* to be followed by two sister-ships, the *Friedrich der Grosse* and the *Grosser Kurfurst,* which were laid down in the earlier seventies. To these were added four small armoured ships of the *Sachsen* class, completed between 1878 and 1884. Then came the *Oldenburg,* a small armoured vessel of 5,200 tons, and in 1890 four ships of the *Brandenburg* class were laid down. These were all the large ships built between 1870 and 1890. They were vessels of an average tonnage of 3,500. In addition, there were a number of sailing frigates and some small cruisers and corvettes for service in foreign waters or for use as scouts.

On the accession of William II. symptoms of a new era soon made themselves felt. A visible proof of this was the laying down of four ships of the *Brandenburg* class. They had a displacement of 10,000 tons, as compared with the 7,400 tons of the *Sachsen* class and 5,200 tons of the *Oldenburg* class. This increase in displacement was a proof that leading circles in Germany now rejected the theory of the former head of the Admiralty, General von Caprivi. He appeared to think that it was sufficient for the German fleet to be able to make sorties or to invest a beleagered fortress. He looked upon warships as a form of coast defense. That fatal phrase, "coast defense," which has created so much trouble, had affected his judgment. With the *Brandenburg* class, however, a return was made to the former sound principle held by Stosch—namely, that the coast can only be defended on the high seas. The *Brandenburg* class is also interesting from another point of view. These ships carried six 28 c.m. guns in the direction of the keel, and were in some ways the forerunners of the *Dreadnought.* They were lacking in weapons of medium calibre, but it must be admitted that the arrangement of the guns was original and might with advantage have been still further developed. To these succeeded the *Kaiser* class, wherein the principle of placing the guns was the exact opposite to that of the *Brandenburg.* These ships had no guns of heavy calibre, only four of 24 c.m., besides eighteen of 15 c.m. This abrupt change goes to show, better than any amount of description, how undecided were leading circles in Germany, and of how much they stood in need of technical and professional experience. Had improved and large ships of the *Brandenburg* class been built instead of the *Kaiser* class, the advantage to the German fleet would have been great, and might have led to a type superior to that of most foreign countries.

In the nineties the fight with the Reichstag over the naval Budget continued, and the consequent uncertainty tended to discourage private yards from preparing for the construction of large battleships. Then came Admiral Tirpitz at the head of the Admiralty—and the exertions of this man are known to all, and particularly to Great Britain. Tirpitz had the original idea of guaranteeing the future of the navy by legislation in such a way that the total strength of each class of ships was fixed and provision made for their renewal after the lapse of a certain number of years. The naval side of the question lies outside the scope of this article, but it has been extensively discussed. Still the law devised by Admiral Tirpitz cannot possibly be left out of account in any review of shipbuilding. The fact that there should be a certain number of ships, and that these should be automatically

replaced when obsolete, afforded the German yards a guarantee which they had not previously had. They could now take the risk of enlarging and improving the equipment necessary for the ever-increasing size of warships. The first naval law was passed in 1898, and was to remain in force for seven years. Amongst leading circles it was by no means agreed as to what private shipyards could do. Inquiries had been made with a view to obtaining information, but the astonishment was general when Admiral Tirpitz declared that six years only, and not seven, would be necessary to carry out the programme.

The Reichstag determined, therefore, to shorten the time limit, and it very soon became evident that German yards were well able to carry to a completion all building requirements demanded of them. Thereby were fulfilled the conditions which the Secretary for the Navy considered necessary before laying the second measure dealing with the fleet before the Reichstag. This time the number of ships constituting the fleet was almost doubled, but it was easy for German shipbuilders to show themselves equal to the occasion; and that is best shown by the fact that the yards, whether State or private, always delivered the ships within the time specified, in many cases even earlier than that contracted for. Further, the estimated speed and horse-power were exceeded.

In 1905, Great Britain, by building ships of the *Dreadnought* and *Invincible* class, initiated a new era in naval construction. For German shipbuilders, as for those of many other countries, the building of the *Dreadnought* was a turning point, and the naval authorities recognized that the moment had come for a thorough overhauling of their shipbuilding programme. Despite the great cost, necessarily increasing in the navy itself, the authorities took the required steps. The greater number of yards were not adapted to the purpose, being specially wanting in slips of sufficient capacity. In the winter of 1905-6 the naval authorities advanced the axiom that in regard to displacement vessels of the new shipbuilding programme must be, whether battleships or cruisers, the equals of corresponding types in other navies. In earlier years the size of ships had been of the least consideration, chiefly on account of cost, but also, perhaps, because it was thought possible to make up for the size of ships by an increase in the numbers of smaller vessels. But in 1905 the strength of each unit became the guiding principle in naval shipbuilding.

During the winter of 1905-6 I made inquiries among the large private shipyards as to how many ships of large displacement, approximating 18,000 tons each, could lay down and within what time they could be completed; and it may be of interest today to give the answers of these yards—namely, each and all were in a position to build battleships or cruisers in twenty-four to thirty months from receipt of order.

Six years have gone by since then, and in the meantime the capacity of output of these shipbuilding yards has been increased in an extraordinary degree. Not only so, but German naval construction shows itself able to stand comparison with that of any other country. The *Nassau* type of vessel aroused no great enthusiasm in England. In my opinion, it is good; but it is a matter for contention. The construction is excellent. They developed an excess of speed on trial, and there was no error in design. It must be allowed that it was something to the credit of the State and private yards that they were able to build ships of 18,000 to 19,000 tons, seeing that hitherto they had built nothing over 13,000 tons. It was the same with armoured cruisers. The *Blucher,* as is known, is only of 15,000 tons gross, because the displacement of the *Invincible* class was falsely given

as being thus. Then came the *Vonder Tann* and *Moltke,* both built in the same private yard—ships which have won the approval of the experts of all nations. The *Vonder Tann* attained a speed of 28 knots. The *Moltke,* of which the trials are not yet completed, would appear to have made 29 knots.

The question has often been raised in England as to whether the German shipbuilders are in a position to build battleships and cruisers in, say, two years. The average time taken at present is three years. I think this question may be answered at once in the affirmative. The shipbuilding yards, on their own showing, were able to do this in 1906; and, considering the experience since acquired, there can be no further doubt on the matter. There is also a large staff of skilled workmen; further, it is as well known in England as in Germany that the time occupied in building a ship is not limited by the actual building, but by the manufacture of the guns. A few years ago the First Lord of the Admiralty declared in the House of Commons that the period of two years for building, as prescribed by the Cawdor programme, was not inclusive, but exclusive, of that required for the guns, not gun-mounting. If I remember rightly, he allowed a further three and six months for these. Now, Great Britain has this advantage, that the Admiralty, previous to a vote in the Commons, can give the order for the guns for the succeeding year. Germany cannot do so, and is in other ways much more dependent upon Parliament. It has often been said in England that the German Admiralty had anticipated their shipbuilding, but this has already been shown to be a mistaken idea. In fact, it is quite impossible, having regard to the Reichstag. As regards guns, there is no doubt but that Krupp, if required, could easily have the gun mountings ready in thirty months, perhaps even in less time.

The power of German-built ships of war will probably soon be shown by orders from abroad. Our shipbuilders naturally attach great weight to this. Competition is undoubtedly keen, more especially since the entry of the United States into the field, and as a Power which will have a constantly growing influence on shipbuilding for South America. But this rivalry in shipbuilding is, in my opinion, of secondary consideration to German shipbuilders, for so long as the German fleet is but in its beginnings the efforts of German shipyards will be chiefly devoted to strengthening it.

Naval shipbuilding in Germany is of but recent date, is young in experience, and may have much to learn; but bearing in mind what has been devised and accomplished in a short time, it is not too much to say that in due time she will overtake her exemplars of the older navies.

In the navy, as in commercial shipbuilding, experiments with the turbine were comparatively long delayed. The first eight battleships of the new programme had reciprocating engines, the *Vonder Tann* having been the first vessel in the German Navy to be fitted with turbines. England had a very great lead. At first the "Parsons" turbine was introduced from England, and there are now several of German origin in an experimental stage. Torpedo boats and small gunboats have for some time been fitted with turbines. The Imperial yards at Kiel and Wilhelmshaven, as well as several private yards, have turbines in course of construction.

Submarine building is also of recent date in Germany, and it is carried out in the "Germania," at Kiel, and in the Imperial Shipyard at Dantzig.

In what follows I hope to give a short description of the principal private shipbuilding yards in Germany, with such details as I have been able to obtain from them. But it would be well to give some general

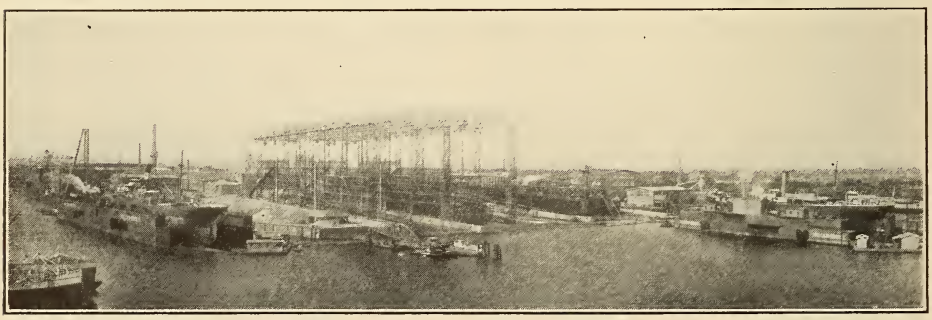
account of the Imperial shipyards. The three yards are situated at Kiel, Wilhelmshaven and Dantzig, have a superficial area of 7,856,000 square miles, and employ, roughly, 23,000 officials and workmen.

The Imperial yard at Kiel has two large slips and a small one for torpedo boats, five floating docks, besides one large one in process of construction, and six dry docks. The yard at Wilhelmshaven has two large slipways, five floating docks, with four small ones for torpedo boats, and seven dry docks. At Dantzig there is a comparatively small slipway, three horizontal slips, a docking basin and two floating docks. This yard is gradually being devoted exclusively to submarines. The Imperial yards are generally confined to repairs, yet they are designed on the principle that they shall possess a sufficient power of output so as to prevent private yards from being in a position to fix the prices at which war vessels should be built.

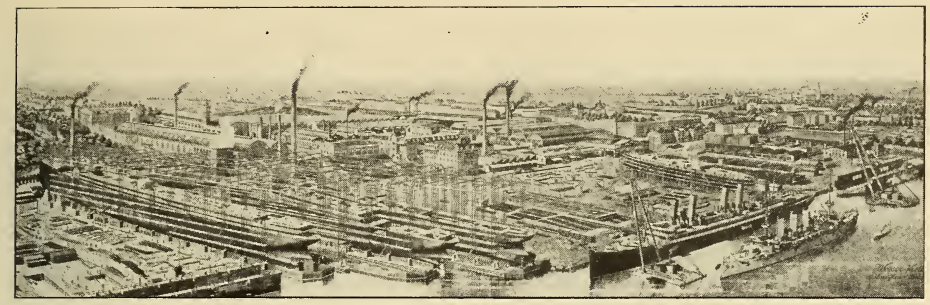
We may take it for granted that it was on this principle that the yards at Dantzig were devoted to building submarines. The Imperial yards have always shown themselves equal to the occasion, and are by no means behind private establishments.

THE VULCAN COMPANY, OF STETTIN

The "Vulcan" was developed out of the shipyard which was founded in 1851 by Früchtenich & Brock, in Bredow. This took place in 1857. In my foregoing observations I have often had occasion to mention the "Vulcan," and this in two different connections. In the mercantile marine the Vulcan became the typical shipbuilding establishment for fast ships after the North German Lloyd, following the example of the Hamburg-American Line, had its ships built in German yards. The fact, also, that the North German Lloyd was bound to have its postal ships built in German yards was of great benefit to the Vulcan. On the other hand, the Vulcan was the first private shipbuilding yard to be in a position to build armoured vessels and to show that far-sighted policy—we had almost said boldness—of adapting itself to great undertakings. In 1868 the German naval authorities made the experiment of building an armoured corvette, the *Hansa,* in the State yard at Dantzig. The Vulcan Company received an order to build a sister-ship; the order hung back, however, for some considerable time, and it was only in 1873 that the *Preussen* was laid down at the Vulcan yard. The efficiency in the case of the Vulcan Company is all the more commendable, inasmuch as the Admiralty had warned the directors not to lay down an expensive plant for building armoured ships, as it was not certain that orders would be given. With the year 1873 came the oft-mentioned order of General Stosch that all warships belonging to Germany, and, as far as possible, all materials, should be constructed in Germany. This undoubtedly acted



SHIPYARDS OF THE VULCAN-STETTIN COMPANY AT HAMBURG



YARDS OF THE VULCAN SHIPBUILDING COMPANY AT STETTIN

as a great stimulus to the Vulcan. The production of its yards may be seen from the following statistics: Since 1871 they have built 110 warships, among which a large number for the Chinese, Japanese, Russian and Greek navies, respectively. Apart from torpedo boats, the Vulcan has received more orders for vessels of war than any other yard, and has, dating from 1900, built a large number of torpedo boats for the German Navy. The Vulcan has built over 159 screw steamers, among them over a dozen mail steamers and about forty Atlantic freight and passenger ships. To these may be added fifty paddle steamers and seven ice-breakers.

The area of the Vulcan yards is 282,400 square metres, of which 91,915 are covered with workshops. There are seven slips, of which two are over 200 m., three between 150 and 200 m. and two of 100 to 150 m. There are two floating docks, one of 100 to 150 m. and another under 100 m. The Vulcan is in a position to build large warships and vessels for the mercantile marine, yet for years there has been an ever-increasing necessity to establish yards on the North Sea. On the one hand, now, was the question of locality, and on the other the draught of water in the Weser. The establishment at Bredow is of the most practical and modern. Round the slips lie the workshops and magazines; light railways facilitate transport between one part and another of the works. They have their own forges and armour-plate plant — in fact, everything associated with an up-to-date shipyard. There are also engine and boiler works, and it may be mentioned that there are, in addition, locomotive and turbine-building works.

The establishment on the Elbe dates from 1906. In that year a beginning was made with the construction of a yard on the island of Ross, within the boundary of the Hamburg Free Harbour. The yard has an area of 226,850 sq. m., with a waterfront of 1,100 m. The yard abuts on the Kaiser Wilhelm harbour, and is connected with the State Railway. Up to the present there are two slips, over 200 m. long, and two large floating docks, while a third, of over 150 m. long, with a lifting capacity of 25,000 tons, is in process of construction. By dredging in front of the slips, the depth of water has been so much increased that the largest ships may be launched and armed. Every mechanical device is at hand. The Vulcan will now be able to compete under far more favourable conditions with other shipbuilders, and it may be anticipated that the yards will pay, notwithstanding the enormous initial outlay. The capital of the Vulcan amounts to 15 million marks, and the last dividend was 11 per cent. The members of the staff and workmen were 12,000 in all. From the point of view of the navy, it is of the utmost importance to possess so efficient a shipyard on the Elbe.

In any war in the North Sea the Vulcan yards, and those of Blohm & Voss, would be immensely valuable for docking and repairing disabled vessels. That the company themselves consider this North Sea branch the most important, is shown by the fact that they have transferred their central bureau to Hamburg since the 1st of October of this year. Nevertheless, the yards at Bredow will retain much of their present importance, for the demands of shipbuilding are great and will continue to increase. The Vulcan is regarded in Germany, and with justice, as having grown up with the development of German shipping and the German naval power, as sharing in all their experiences, and as having always risen to the height of its demands.

THE SHIPYARD F. SCHICHAU, OF ELBING AND DANTZIG

This is the unique and largest shipbuilding yard in Germany, which is not a limited company, but remains in private hands. The Schichau works were founded in 1837 by Ferdinand Schichau, at Elbing, and are now owned by his son-in-law, Geheimrath Zeiss. Ferdinand Schichau was a man whose abilities may not unjustly be compared with those of Alfred Krupp, founder of the works of that name. He started the works at Elbing for engine building in 1837, and, ten years later, obtained the first order for a marine engine. Henceforward the works developed more and more in the direction of shipbuilding, and began with building dredges, which are to-day one of the specialties of the firm. In the early fifties the Prussian Government approached the Schichau works as to building the engines and boilers for the corvette *Dantzig*. I mention this otherwise unimportant fact to show the intimate connection which has existed between the firm of Schichau and the Prussian, later the German, Government, relations which have proved of the greatest importance, both in matters of shipbuilding and torpedo-boat construction. Later the firm confined itself to its original engine building, until in 1855 the iron ship *Borassia* was built in their newly established shipyard. Shipbuilding now developed apace, and in the early seventies a second ship was constructed, in partnership with the engineer Zeiss, the present owner. The Schichau engines proved themselves as superior as the materials used in the construction of the torpedo boats. In the seventies the Prussian Government gave an order for a spar-torpedo. The brilliant result of this boat and its successes laid the foundation of the firm's fame in this branch of their productions. In the eighties the German Government turned to the torpedo, and Captain Tirpitz—as he then was—developed the type of boat and the general organization. The superiority of the Schichau-built boats lay chiefly in their light displacement, speed, large radius of operations and seaworthiness, even in rough weather, large coal capacity and comfort. In open competition, in 1884, Schichau obtained the preference, and ever since, up to the beginning of the present century, has built almost all the German torpedo boats. The reputations of these torpedo boats brought them numerous orders from abroad. Great attention was drawn to them when a torpedo boat of 140 tons, ordered by China, reached Foochow in sixty days, going under its own steam, without parent ship. As is well known, other builders besides "Vulcan" and "Weser" have entered into competition with Schichau in the domain of torpedo boats, but the distinction of being the inventor of the German torpedo boat belongs to Schichau. That is proved by the fact that our torpedo boats of the present day preserve the type of the original Schichau boat.

At the end of the eighties the firm of Schichau acquired a yard at Dantzig, as they intended to devote themselves also to the construction of large vessels, and from 1890 onwards cruisers and battleships have been

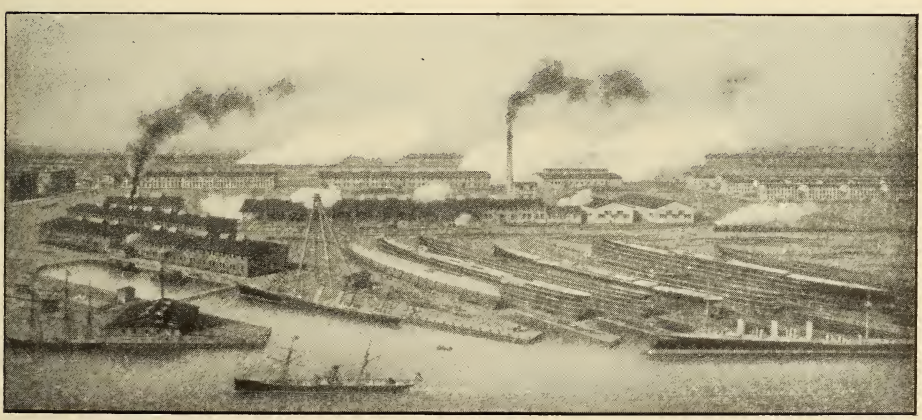
STEEL FOUNDRY AT THE SCHICHAU WORKS, ELBING, PRUSSIA

built for the German Navy, as also for other foreign navies. In addition, it must be noted that several large liners have been built for the North German Lloyd.

The works have grown with every demand made upon them, and would be more than equal to any extraordinary efforts which might be required of them in the matter of rapid shipbuilding by the German naval authorities. The ground covered by their yards at Elbing, Dantzig and Pillau amounts to more than 87 hectares. The staff and workmen generally number 8,000. The yard at Elbing has nineteen slips for torpedo boats and two docks; that at Dantzig seven slips, of which four are adapted for ships of the largest tonnage. The slips are supplied with the most up-to-date appliances, such as electric cranes, etc. The present owner, like his predecessor, the founder, belongs to that band of great organizers of labour and distinguished experts.

BLOHM & VOSS SHIPYARD

In 1877 the shipbuilding yard and engine works of Blohm & Voss were founded on the island of Steinwerder, in the Elbe, and were at first but small and of little importance. The position of the enterprise to-day is most important. In 1911 the yards employ 7,500 men. The works cover 460,000 square metres, of which 300,000 have been built upon, and the waterfront is 2,570 m. long.



THE SHIPBUILDING YARDS OF F. SCHICHAU AT DANTZIG

There are ten slips, of which four are over 200 m. long, five between 150 and 200 m., and a small one of less than 150 m. There are floating docks, the largest of which has a lifting capacity of 35,000 tons, and there are others of capacities of 17,500, 17,000, 4,700 and 3,000 tons. Two of these—the largest and the third—can be transported, and, in case of war, would be of great service to the fleet in the Elbe. In 1881 Blohm & Voss were turned into a limited liability company, with a capital of six million marks and loan on mortgages of eight million marks. A dividend of 6 per cent was paid in 1910.

The yards are used for the construction of all kinds of ships, but a specialty is made of floating docks. In addition to shipbuilding, there are large works for the construction of steam engines and turbines. There are two boiler-making establishments for cylindrical and water-tube boilers. Lately a foundry for bronze and steel has been added. In short, there is every modern requirement, both as regards machinery and equipment generally.

Shipbuilding of any importance for the German Navy dates back only a comparatively short time. This began in the eighties with the small cruiser *Kondor,* followed in the nineties by the battleship *Kaiser Karl der Grosse,* of about 11,000 tons; and from that date an uninterrupted series of armoured cruisers. Beginning with the cruiser *Friedrich Karl,* launched in 1902, there followed the *York, Scharnhorst, Vonder Tann, Moltke, Goben,* and the cruiser *J,* of the 1910 programme, not yet launched. The building of armoured cruisers has been specialized by Blohm & Voss, and the cruisers *Vonder Tann* and *Moltke* have given them a reputation throughout the world. This was also the first German shipyard to make arrangements on a large scale for the construction of turbines, the cruiser *Vonder Tann* having been the first large cruiser fitted with the turbine. Several years earlier the firm had received the second prize for the best plan of an armoured cruiser, and, shortly afterward, the prize offered by the Russian Government for a new type of battleship. The works have in the last decade advanced enormously in the matter of battleship building, and can compete in this branch with any firm in the world. In war, the position of the yard on the Elbe would be of great advantage as a repairing and refitting basis to Germany.

Messrs. Blohm & Voss have built a large number of steamers of all kinds for the mercantile marine, notably for the Hamburg-American and North German Lloyd lines. Besides this, they have built vessels for the Hamburg South American Line, for the Woermann, the German East African and the Kosmos lines. A considerable amount of the firm's activity is devoted to repairing vessels, as their position in Hamburg harbour and their possessing manifold modern appliances stand them in great service. The number of workmen varies between 5,500 and 8,000. The yards of Blohm & Voss grow yearly in importance.

THE HOWALDT WORKS

These works were started and opened as a shipyard in 1876 by their founder, Howaldt, and have only recently been turned into a limited liability company, up to which time they were the private property of the Howaldt family. The yards are in Kiel harbour. In 1876 there were only 450 square metres covered with bulidings, and a total ground area of 20,000 square metres. To-day there are 35,515 square metres covered with workshops, and the total area amounts to 735,695 square metres. The yard can, therefore, be very much enlarged. In these yards there is evidence—more, perhaps, than in any other—of the extraordinary growth of German shipbuilding. The old yard remains, but new and enlarged shipyards have been con-

structed. The original shipyard is principally utilized for the lighter and least important work, but the work is centralized. The Howaldt works have a waterfront of fully 2 k.m., one of which is arranged as a quay. This company has a capital of seven and three-quarter million marks. They have had difficulties of recent years, and no dividend has been paid, but there is every ground for believing that this period of adversity is over. The shipyard has six slips, one of over 200 m. length, two over 150, two over 100 and four less than 100 m. long. There is also a floating dock. The number of employees amounts to 3,500. A turbine manufactory is in process of construction.

Since 1876 Howaldts have built numerous ships of all sorts and sizes, more especially for abroad, among others, the Russian schoolship *Okean.* Floating docks, floating cranes and dredgers form also part of their output. Modern naval construction by this firm is comparatively recent. Their first modern cruiser, the *Undine,* was begun there in 1901. There soon followed a battleship of 20,000 tons—namely, the *Helgoland*—which has just finished her trials. In the spring of 1910 the battleship *Ersatz Hagen* was laid down at Howaldts. It may be expected that the Howaldt yards will soon be in a position equal to that of any other German yards for building large men-of-war.

THE WESER COMPANY

The Weser Limited Liability Company was founded in 1872, having been originally C. Waltjen & Co., established in 1843. The business was, from the beginning, remunerative, and the firm got many orders for mercantile ships, as also ships of war, though these were of comparatively small size. As ships grew larger with time, the yards proved too small, and an extension on its original situation was impossible. In consequence, the whole establishment was transferred to Gröpelingen, a suburb of Bremen, and the new works were gradually completed between 1901 and 1905. The shipyard as it now is, is entirely new and entirely up-to-date, having no old equipments. This is, naturally, a very favourable position to be in, but to ac complish this entailed a very heavy outlay. On completion of these works the company became one of the important shipbuilding companies of Germany. They employ about 5,000 officials and workmen. There are five slipways, one over 200 m. long, another over 150 m., one over 100 m. and another less than 100 m. long. There is a floating dock of 100-150 m. long. The construction of two further slips has been begun. The dockyard harbour is 1,200 m. long, and the largest ships can easily be launched. The works cover an area of 600,000 sq. m., and there is a waterfront 1,200 m. long. Capital, 7½ million marks. No dividend last year.

Mercantile ships were chiefly built for the North German Lloyd. The latest were the *Goben* and the *Lotzow* and the transatlantic steamer *Berlin,* of 28,000 tons, the largest vessel built up to that time on the banks of the Weser. The company also built the first longitudinal-ribbed vessel in Germany. It will also be of particular interest to learn that the Hamburg-American Line has ordered this year a 6,500-ton cargo steamer, to be driven by oil motors. The vessel will be 350 feet long, 50 feet beam, with a depth of 22 feet 6 inches. There will be two motors on the "Junkers" system, each capable of developing 800 effective horsepower. The speed is 10 knots. The auxiliary engines will be driven at sea by compressed air and electricity and in harbour by steam.

The yard supplied the navy with a considerable number of vessels, such as gunboats and small cruisers; but when the new yards were established at Gröpelingen it was possible to take orders for battleships and armoured cruisers. In 1907 the order for the battleship *Westphalen,* of the

Nassau class, of about 18,000 tons, was placed here, although no battleships had previously been built, only cruisers and gunboats. The vessel was delivered in prompt time and successfully underwent all the trials. A short time ago the *Thuringen* made her trial runs, and recently the battleship *Ersatz Weissenberg* was laid down. This yard has, therefore, in a very short time showed itself capable and efficient for building the largest class of vessel. They have introduced, also, a turbine on a system of their own, and known as the "Weser-Bergmann." The two small cruisers, the *Magdeburg* and *Ersatz Kormovan,* will be the first vessels of the Imperial Navy to be fitted with this turbine system. The *Thuringen* has reciprocating engines, but the *Ersatz Weissenberg* will be fitted with turbines. Tests are being made in the German Navy of a number of turbine systems with small cruisers. On the results of their experiments will depend which system is to be fitted to the battleships.

THE KRUPP "GERMANIA" YARD AT KIEL

The "Germania" yard has a curious history, inasmuch as it had its beginning, not on the seacoast, but inland. It derives its origin from a small foundry and workshop which was founded by F. A. Egells in 1822, in the neighbourhood of Berlin, and employed only 10 men. The works were gradually enlarged and frequently received orders for marine engines and boilers. In 1871 works were started at Tegel, near Berlin, and became the "Märkisch-Schlesische Maschinenbau- und Hütten-Aktiengesellschaft." The great industrial progress in Germany brought many orders for ships' engines and boilers. These became the specialties of the firm, and it was a natural consequence that they should turn to shipbuilding. In 1879 the company bought the "Nordeutscher" yard, at Kiel, and in 1881 the two branches were united under the name of the "Schiff- und Maschinenbau-Aktiengeselschaft Germania." Under this designation the yard has produced much good work, and built a number of mercantile and naval vessels for home and abroad. As of interest in naval history, it ought to be mentioned that the cruiser *Kaiserin Augusta* was built in the "Germania" yard, the first German warship to be fitted with triple screws and to reach the then exceptional speed of 22 knots. The *Fuerst Bismarck,* the first German armoured cruiser, launched in 1897, was built by the "Germania." In 1896 Friedrich Krupp, of Essen, took over the yard on a twenty-five years' lease. By the terms of the contract the firm of Krupp stipulated that they might make any alterations in the situation they might deem necessary. They also reserved the right to acquire the yard for themselves. The moment for this occurred in 1902. On the 1st of April of that year this yard became the possession of Krupp, under the name of "Friedrich Krupp Aktiengesellschaft Germania - werft." It then entered upon a new period of development. Many millions were invested in the new plant, and nothing was spared in making the establishment one of the largest and best-equipped in Germany. This has happened, and the "Germania" is now equal to the greatest possible demands which may be made either for the construction of naval or mercantile ships. The area covered by the works is 235,000 sq. m. There are four slips of between 150 and 200 m., three between 100 and 150 m., and six under 100 m. The "Germania" does not possess a dock. There are 4,000 workmen employed. The capital belongs to the Krupp, Essen Company. The "Germania" stands alone in Germany in so far that it produces its own guns and armour. The purchase of the "Germania" yards would appear to have been a favourite idea of the late Herr Krupp, and it is well to draw attention to this, as its development

is being pushed forward by every possible means. The first German shipbuilding works to be covered in were constructed, and a passing visit will show that no expense has been spared. Battleships, cruisers, torpedo boats, and, as a specialty, submarines, are built. The *Posen,* of the "Nassau" class, was built here, and the *Ersatz Odin* is now on the stocks. The "Germania" yards had previously built eight ships of war for the German Navy. Torpedo building was formerly almost exclusively confined to Schichau. For many years "Germania" had built torpedoes for foreign governments, and at the beginning of the present century began to build regularly for the German torpedo flotilla, with excellent results. Experiments were also made with submarines, and in 1902 the first submarine, the *Forel,* was delivered to Russia, to be succeeded by others. A few years later the first submarine for the German Navy was built, and proved in every respect a satisfactory type.

Mercantile vessels are also being built, and a large number have been supplied to the orders of the "North German Lloyd" and "Hamburg-American" Lines, as well as large numbers of tugboats, railway steamers, dredgers and freight steamers.

The "Germania" has also taken up the turbine, and alone produces the water-tube boilers and the system Schultz. Furthermore, she builds oil motors and all engines and boilers installed in ships of her building.

The Krupp-"Germania" has this difference as compared with all the other German yards, that she has not gradually developed, but has been made at one stroke, by means of the Krupp millions, a great and modern yard. Her power of production, as that of most of the German yards, is far superior to the present demands likely to be made upon it.

THE FLENSBURG SHIPBUILDING COMPANY

This yard is less known than it deserves to be, for it stands to-day among the most efficient in Germany. It was founded in 1872 by merchants of Flensburg, and devoted itself exclusively to building merchant ships. Its workshops have recently been largely extended. Ships of more than 10,000 tons are built, and there is an agreement with Sir Raylton Dixon & Co., of Middlesborough, for the sole production in Germany of their "Patent Cantilever Framed Self-trimming Steamers." The output of this yard is very high, and in 1906 amounted to 46,000 tons register. They built for the Elsenburger shipyard the large off-shore dock. Docks and pontoons are their special line.

The equipment of the yard is up-to-date, and large freight and passenger steamers are built. Much attention is given to ship repairs. The works cover an area of 178,000 sq. m. There are two slips over 160 m., three of 100 m., and a floating dock, while there are 2,000 employees. The share capital is 3.3 million marks. Warships have not yet been built by this company.

TECKLENBORG SHIP & ENGINE BUILDING WORKS, BREMERHAVEN-GEESTEMUNDE

This yard was founded in 1841 by Herr J. C. Tecklenborg, in Bremerhaven; but, on beginning to build iron ships, was transferred to Geestemünde, where it has since remained. In 1897 it was turned into a limited company, and has to-day a capital of four million marks. The area of the works covers 210,000 sq. m. There are two docks over 200 m., one over 150 m., and one less than 100 m. The equipment is up-to-date, and there are some 5,000 employees. There is a waterfront of 1,500 m., with quays of 300 m.

About 300 ships have been built by the firm, and at the present time they specialize in large steel sailing ships, of three, four and five masts. Well-known ships of this class were the *Potosi* and *Preussen.* The latter has a displacement of 8,200 tons. The development of this branch of

shipbuilding brought them to the front as builders of sailing ships. The company has also built largely for the "North German Lloyd" and the "Hamburg-American." Of late years small naval ships have been built, among which the gunboat *Otter* may be mentioned. In addition, engines and boilers are made, not only for vessels of their own building, but also for outside firms. Having devoted attention for a considerable period to oil motors, an order has recently been received from the "Hansa" Steamship Company for a motor-driven vessel of 2,000 tons. It will have a six-cylinder motor of 1,500 horse-power. The auxiliary engines are also driven by oil motors.

THE BREMER "VULCAN"

This company has no connection with the Stettiner-"Vulcan." The name of the company is "Bremer Vulcan, Schiffbau- und Maschinenfabrik Vegesack." The beginnings of the company date back to a small shipbuilding yard, which was founded early in the nineteenth century by J. Lange, in Grohn bei Vegesack. Herr Lange did wonders, and brought his yards to a state of perfection then little known in Germany. He built the first German steamboat, and this was in 1817, shortly after the first English steamer had made her trials on the Clyde. The vessel was christened *Weser,* and ran on the Weser. It will interest English readers to learn that the designs for the engines of the *Weser* were prepared by James Watt, and are still preserved by the company.

In the early nineties, during a period of commercial depression, the business was turned into a limited company, and thus was founded, in 1893, the "Bremer Vulcan" Company. Succeeding years brought important developments, the company buying the old yard and the ground now occupied by its shipyards. There is an area of 332,000 sq. m. and six slipways, all over 100 m. length. The staff numbers, roughly, 3,000.

The Bremer Vulcan has had large orders from the North German Lloyd, Hamburg-American and other lines. In 1902 the shipyard was still further enlarged, and now possesses a waterfront of 1,500 metres in length.

The equipment is in every respect excellent, and it is in a position to build rapid, large, first-class transatlantic steamers. In contrast to other yards, the Bremer Vulcan devotes itself almost exclusively to new construction, very little repairing, as was formerly the case, being done, and so its productive power is comparatively great. Naval shipbuilding has not hitherto formed part of the enterprise.

THE REIHERSTIEG-SCHIFFWERFT

This company derives its name from the fact that the yards are situated on a tributary of the Elbe bearing that name. The yard is relatively, for Germany, very old, as it already existed in 1706. Since then there have been many extensions, and notably in 1902. The share capital amounts to four million marks, and the works cover an area of 68,300 sq. m. There are two slips of 100 to 150 m. length and two floating docks of the same length. Two thousand workmen are employed. Since 1881 something like 450 ships and ships' hulls have been built, and there has also been a large output of engines and boilers. The two above-mentioned floating docks are of English origin. Another floating dock of 10,000 tons is being built for them.

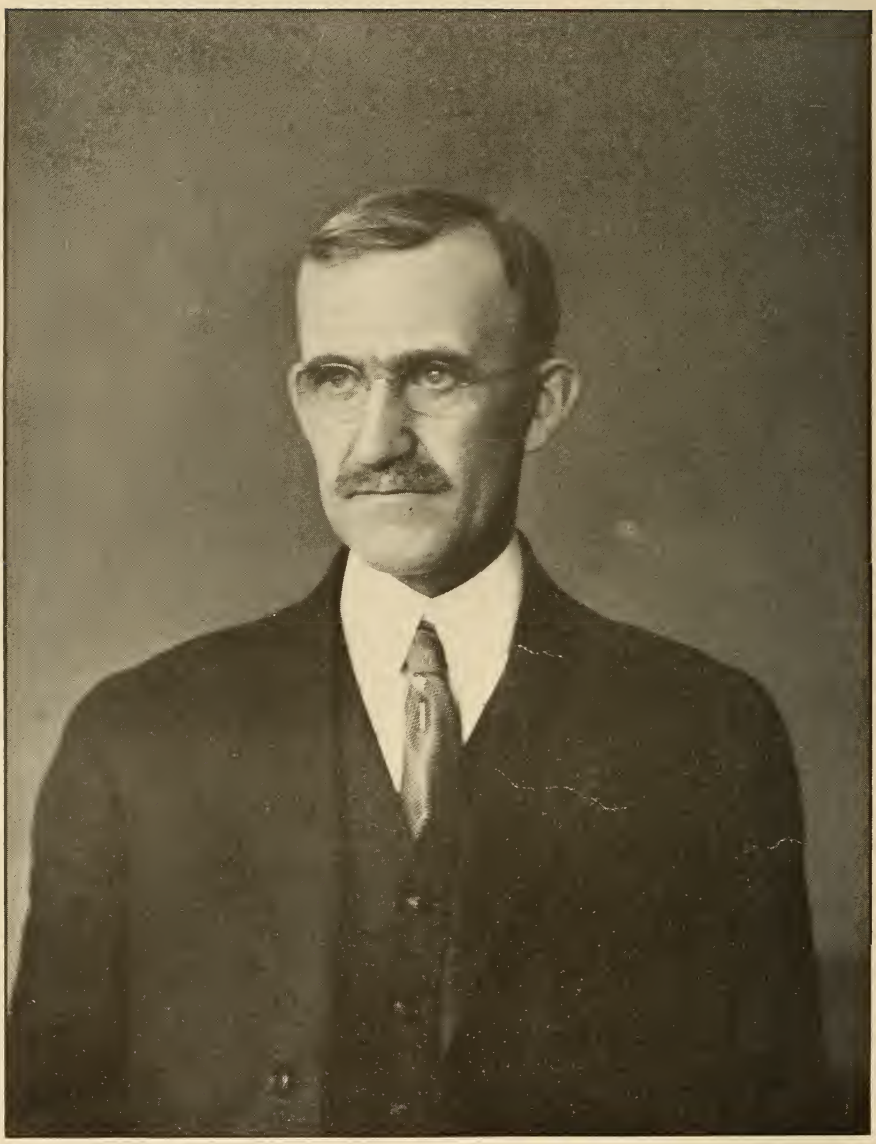
The Reiherstieg has had an uninterrupted flow of orders. The names of all the principal companies will be found on their books. The plant is quite up-to-date, and the company has also devoted attention to oil motors on the Diesel system. They are at the moment building a Diesel motor of 1,800 horse-power for the steamship *Excelsior,* of the "British American Petroleum Company, of Hamburg."

Mr. Henry H. Quimby, whose portrait we publish in this issue, was born at Womelsdorf, Pennsylvania, in 1858, and received his education in the Philadelphia High School, after which he entered the employ of the Phoenix Iron Works, at Phœnixville, Pa. His early experience was gained in the machine shop, where he acquired a sound practical knowledge of construction, and from which he passed to the drafting department, becoming successively draftsman, checker, chief draftsman, and chief engineer. During this portion of his career, Mr. Quimby was actively engaged in the development of modern steel building construction, as well as in the design and construction of a number of important railway bridges, these latter including the cantilever bridge of the Atlantic & Pacific Railroad over the Colorado river, at Bed Rock, Colo., the bridge over the James river at Richmond, Va., and over the Hudson, at Albany.

From the service of the Phoenix Iron Works, Mr. Quimby passed to the position of Bridge Engineer of the city of Philadelphia, and in that capacity he designed and constructed more than sixty bridges for Philadelphia, including stone, concrete, structural steel, or reinforced concrete construction. The most notable of these include the long-span highway bridge over the tracks of the Pennsylvania Railroad at Forty-second street, the double-leaf bascule drawbridge, over the Schuylkill river, at Point Breeze, and the large concrete arch over the Wissahickon at Walnut Lane.

Early in the year of 1912 Mr. Quimby severed his connection with the city of Philadelphia to associate himself with Mr. John G. Brown, in the design and construction of mills, factories and warehouses, with headquarters in Philadelphia.

Mr. Quimby is a member of the American Society of Civil Engineers, and a member of its committee on Concrete and Reinforced Concrete; a member of the American Society for Testing Materials, and of the National Association of Cement Users; and is a Past President of the Engineers' Club of Philadelphia.



HENRY H. QUIMBY

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INDEXED

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XLI MAY, 1912 No. 5

PORT OF SOUTHAMPTON

By Mark Meredith, M. E. A., M. I. S. A.

THE position of the port of Southampton is that of England's premier passenger port, and no further evidence of this is needed than the fact that 304,045 passengers and 47,968 troops, giving a total of 352,013 persons, arrived in the port departed from the docks in 1910. The geographical position of the port is not only unique, in that it is situated almost midway on the coast line of the English Channel and within easy access by rail to the metropolis, but it is blest with the unusual natural advantage of double tides, which give it virtually four hours of high water twice a day—an advantage enjoyed by no other port in the world. The harbour itself is landlocked but for the east and west entrances, and the very moderate tidal range, with a slow flood tide, is a boon that cannot be too highly valued, for it not only makes the port very acceptable, but minimizes the cost of dredging.

With the early history of the port we cannot deal at very great length, but the first steps taken in regard to the construction of docks for Southampton were contemporaneous with the commencement of the London & Southampton Railway, as the present London & South-Western Railway then was, and August, 1836, saw the old Southampton dock in existence. This dock was 16 acres in area, with 300,100 feet of quayage, with a depth at low water of 18 feet, but it accommodated the boats of the Peninsula & Oriental Steamship Company in the latter part of 1842, when their mail service was commenced under Government to the West Indies. The foundation stone of the docks was laid on October 12, 1838, and this dock marks the extreme northwest limit of the dock estate, and thus discloses the original intentions of the promoters to construct a closed dock first. This was, however, discarded in favour of an open dock, now known as the Inner Dock, which duly made its appearance in the position originally proposed in 1851, and consists of an area of ten acres, with a depth of water of 27 feet. While this work was in hand the provision of graving docks was pushed forward with due regard to the shipping requirements of the port, and by the year 1873 the whole of the dock accommodation consisted of the outer and inner docks and four graving docks; but on August 21 of that year the quay on the river Itchen, known as the "old extension" quay, was commenced, and finished in 1876. Up to the year 1890 Southampton was just able to

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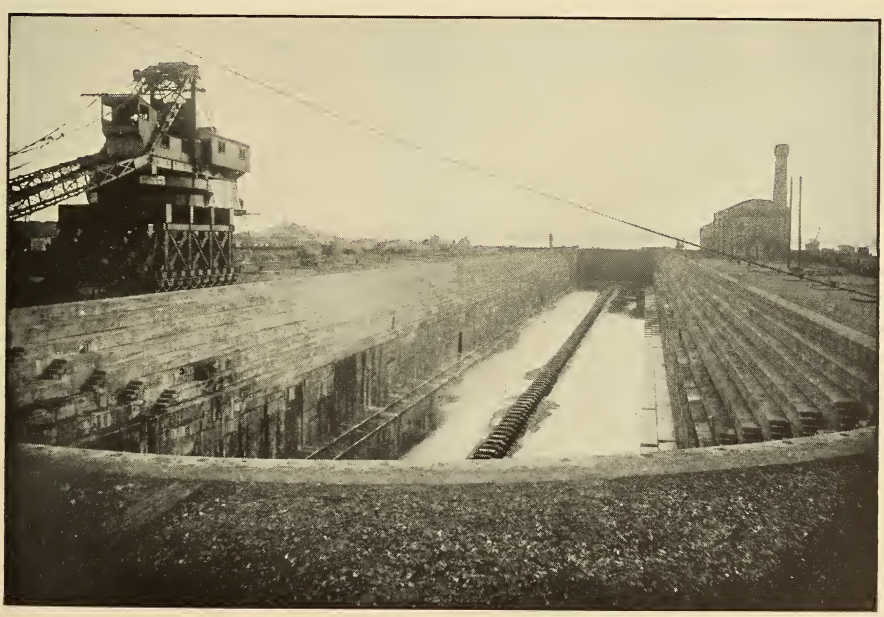
MAP OF THE PROPERTY OF THE SOUTHAMPTON HARBOUR BOARD

keep the largest vessels afloat at high water, but that year saw the opening of the Empress Dock, possessing an area of 18½ acres and a minimum depth of 26 feet at low water. This was the commencement of a new era in the dock accommodation of the port, and in November, 1892, the estate was sold by the Southampton Dock Company, then the owners of the docks, to the London & South Western Railway Company, and since that time a forward policy has been pursued with unabated energy. The first work of the Railway Company was to construct the Prince of Wales Graving Dock, the foundation stone of which was laid in August, 1893, and the opening of which, by King Edward VII., took place on August 3, 1895. This graving dock is 750 feet long, 112 feet wide, and is capable of holding 14,500,000 gallons of water, with which it can be filled in ninety minutes and emptied in two and one-half hours. The provision of still further deep water accommodation was undertaken, and the Prince of Wales Extension Quay, 2,000 feet long, to the south of the entrance to the Empress Dock; the south quay,

430 feet long, and the Test quay, 1,600 feet long, were added. Soon further dock accommodation was needed, and in 1905 the Trafalgar Dock was opened. This dock had a length of 875 feet, with an entrance depth of 90 feet, and a capacity for 85,000 tons of water, which could be emptied in two and one-half hours. A period of only three years had elapsed before it was found necessary to provide further graving dock accommodation, and it was eventually decided to increase the size of the Trafalgar Dock so that its length would be 897 feet, its entrance 100 feet, and the depth over the sill 35 feet. The Trafalgar Dock in its original state was designed by Mr. W. R. Galbraith, lately vice-president Inst. C. E., and the contractors were Messrs. John Aird & Co., of London; but Messrs. Topham, Jones & Railton, Ltd., are carrying out the alterations, whilst the electric crane is by Stothert & Pitt, Ltd., Bath. The pumps supplied for dealing with the water are by Gwynne's, Ltd., Hammersmith, whilst a new caisson is being supplied by Sir W. Armstrong, Whitworth & Co., Ltd., Newcastle. Messrs. Gwynne's also supplied the pumps for the Prince of Wales Graving Dock and Messrs. Stothert & Pitt the electric crane therefor. The widening and lengthening of the Trafalgar Dock, which has been undertaken by the railway company, is being effected by cutting away the face of both walls and setting back the altars, and to compensate for the weight thus lost counter fort walls are being built at the back of the existing walls. The design for and supervision of these works have all been in the hands of the docks manager, Mr. T. M. Williams, while Mr. F. H. Wentworth-Shields has also been associated in the work.

The most important work on hand, however, is the new deep-water dock which is being constructed by the railway company, and which is rapidly nearing completion. Already one berth is completed and is constantly used by the White Star monster vessel *Olympic*, and of which a photograph is given. The dock itself is a parallelogram in shape, with a length of 1,700 feet and a width of

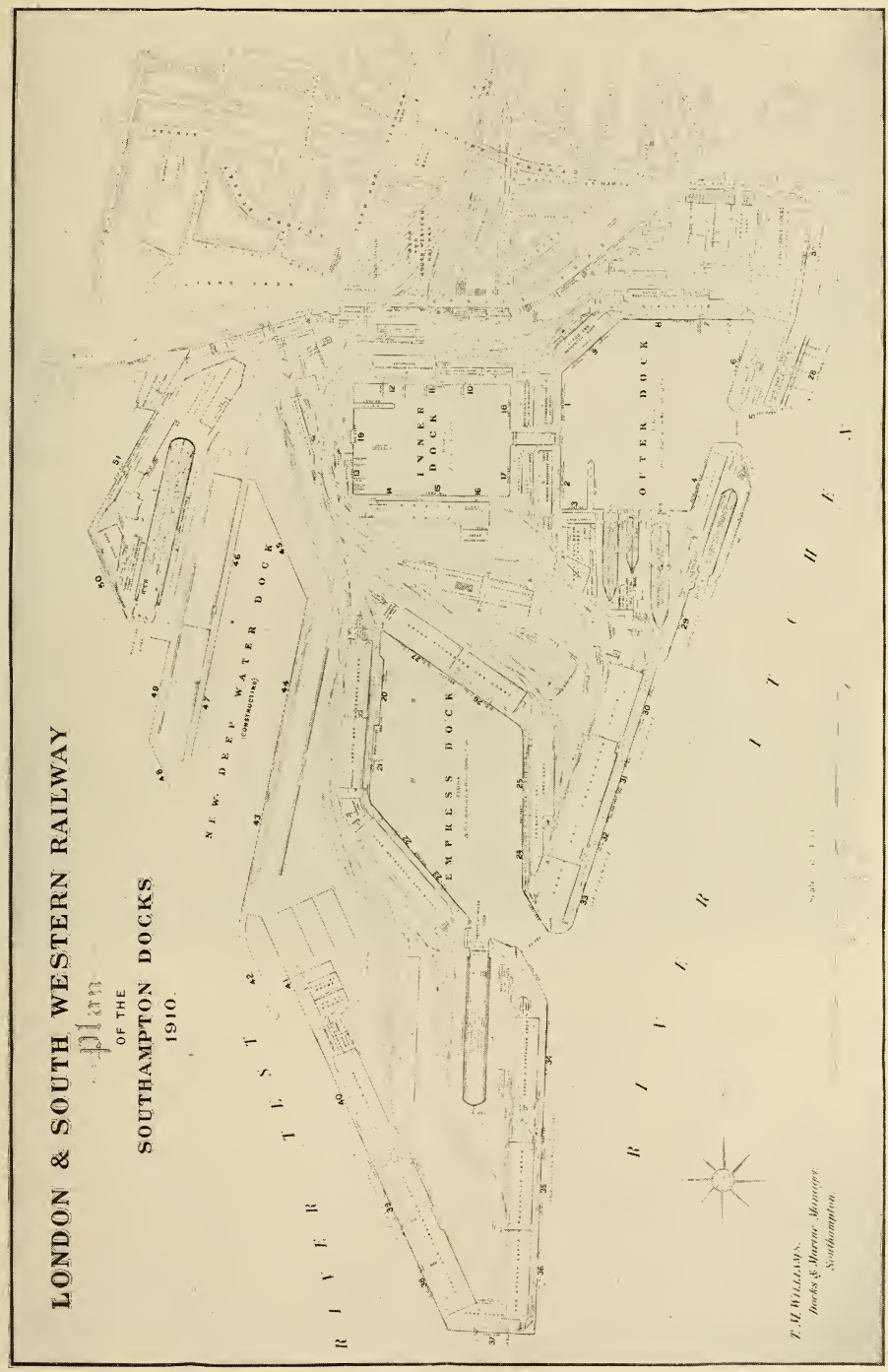


TRAFALGAR GRAVING DOCK, SOUTHAMPTON

400 feet. It has a depth at low-water ordinary spring tides of 40 feet, and at high water the depth will be 13 feet more than this. There is no entrance lock, but it will be seen from the figures given that the largest vessel will be able to lie afloat here at any state of the tide without risk of touching the bottom. The dock is large enough to hold five vessels; two vessels of the largest type can berth on each side of the dock and a short vessel against the small end berth.

The dock is surrounded with quay walls constructed entirely of Portland cement concrete. The quays are being equipped with four large steel cargo sheds, one of which is already built at the berth where the *Olympic* lies. The shed which is completed has a length of 640 feet and a width of 120 feet, with an annex of 60 feet by 60 feet, containing stores for baggage and dock gear. The framework of the sheds is of steel, the sides being covered with corrugated sheeting and the roof with planking protected with Graves' felt. The steelwork has been erected by Messrs. Heenan & Froude, Ltd., of Manchester. The foundation consists of concrete piles driven on the "Simplex" system, and the flooring is of timber. Besides the stores in the annex, a set of waiting rooms and lavatories is provided at the southern end, with cages for bonded cargo and offices for the medical officer, foremen and clerks. Along the front of the shed is a high-level balcony, onto which passengers pass direct from the vessel, and which communicates with the floor of the shed by means of two wide staircases. The shed itself is built in two spans of 60 feet, the central columns being spaced 30 feet apart. At the back of the shed is a line of rails and a platform at which the passengers join the train. The examination of baggage takes place close alongside in the shed, so that passengers are under cover the whole time when

THE OLYMPIC ARRIVING AT THE NEW DEEP WATER BERTH, SOUTHAMPTON

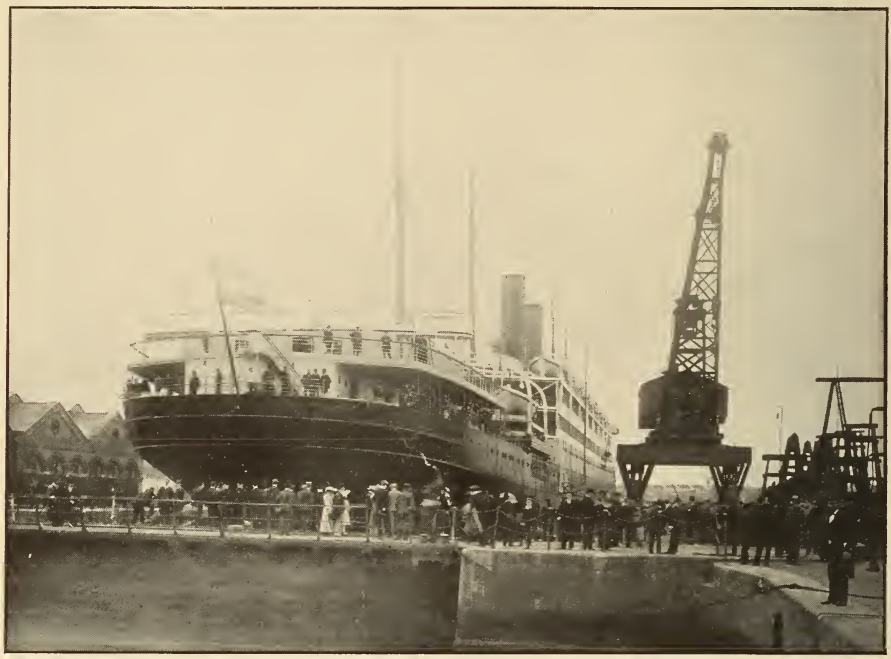


THE SOUTHAMPTON DOCKS OF THE LONDON & SOUTH WESTERN RAILWAY

passing between the ship and the train. The quay space between the ship and the shed has a width of 35 feet. This is covered with timber decking, and has two lines of rails for trucks, as well as a line of rails for the large electric cranes which deal with the cargo. Four of these cranes are provided for the berth, two of which are capable of lifting 5 tons and the other two of lifting 35 cwt. They are built by Messrs. Stothert & Pitt, Ltd., of Bath. There are also provided two moving bridges, or stages, across which passengers walk from the ship's side to the balcony on the shed. All the rails are connected up to the elaborate system of sidings which now exists on the docks. A block of offices for the White Star Line has been built by Messrs. Perry & Co., of Bow, London.

Besides the dock itself four outside quays are being constructed, of lengths varying from 330 feet to 610 feet and with depths at low water of from 25 to 32 feet. These quays are all in an advanced state, and it is expected that they will be completed towards the end of the year.

The contract for the construction of the dock was let to Messrs. Topham, Jones & Railton, Ltd., in October, 1907. Before the works were commenced the site of the dock consisted, for the most part, of a bare mudland facing on the river Test, and although the works are still incomplete, the following quantities have been dealt with: 873,000 cubic yards of open excavation, 316,000 cubic yards of trench excavation, 807,000 cubic yards of dredging, 272,000 cubic yards of concrete laid, and 42,000 tons Portland cement used.



THE AMERIKA AT THE PRINCE OF WALES GRAVING DOCK, SOUTHAMPTON

The works have been in hand about three and one-half years. During the whole of this time the number of men employed has been generally about 800 to 1,200. A very fine set of plant has been laid down.

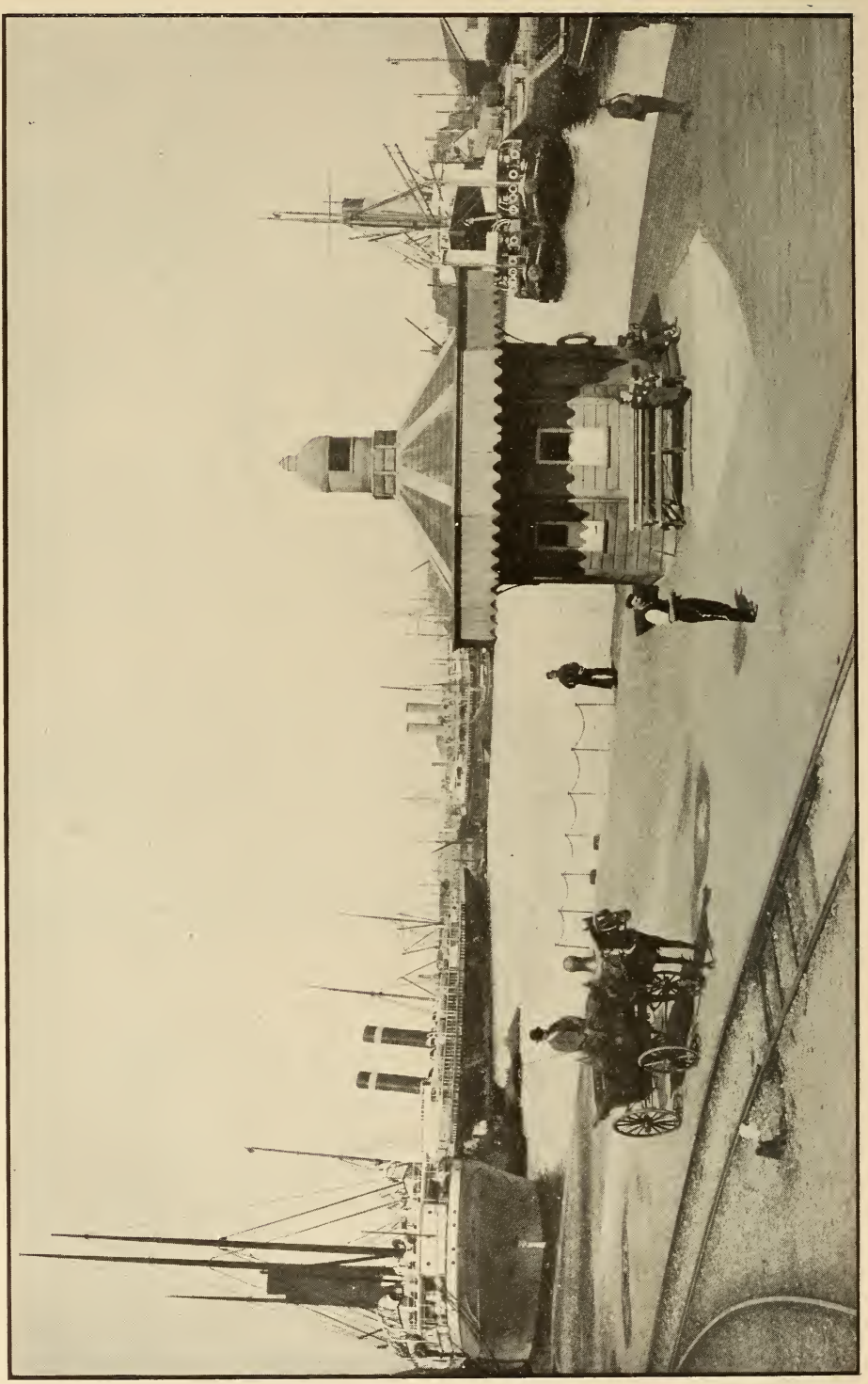
Eighty-five machines have been at

ARRIVAL OF H. M. TRANSPORT REWA AT SOUTHAMPTON DOCKS

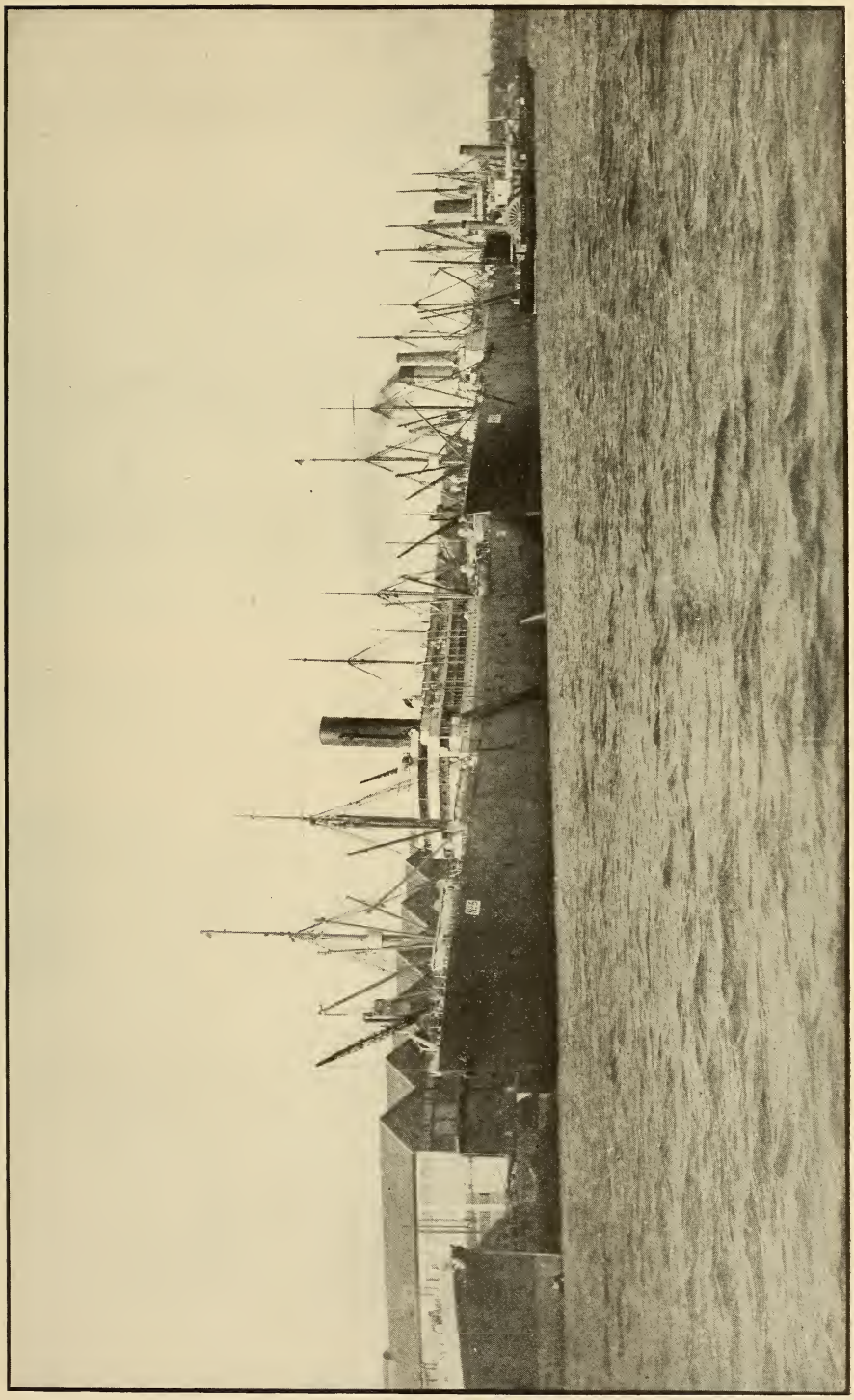
work, including locomotives, steam navvies, crane pumps, pile-drivers, winding engine, air compressors, etc. Twenty divers, in dress and helmet, have been employed in setting concrete blocks and other submarine work. No effort has been spared to push the works to a rapid and successful completion.

Another interesting piece of engineering work was carried out some time ago at the old Extension Quay, as it was found advisable to increase the depth of water from 20 feet to 28 feet and 30 feet, and also to widen the quay for a distance of 50 feet, to enable dredging to be carried out without endangering the stability of the quay wall. The method adopted was that of the Hennebique system of ferro-concrete piling work, upon which a platform was formed of rolled steel beams with timber planking, in which the rails are laid to carry the trucks and the cranes for dealing with cargo.

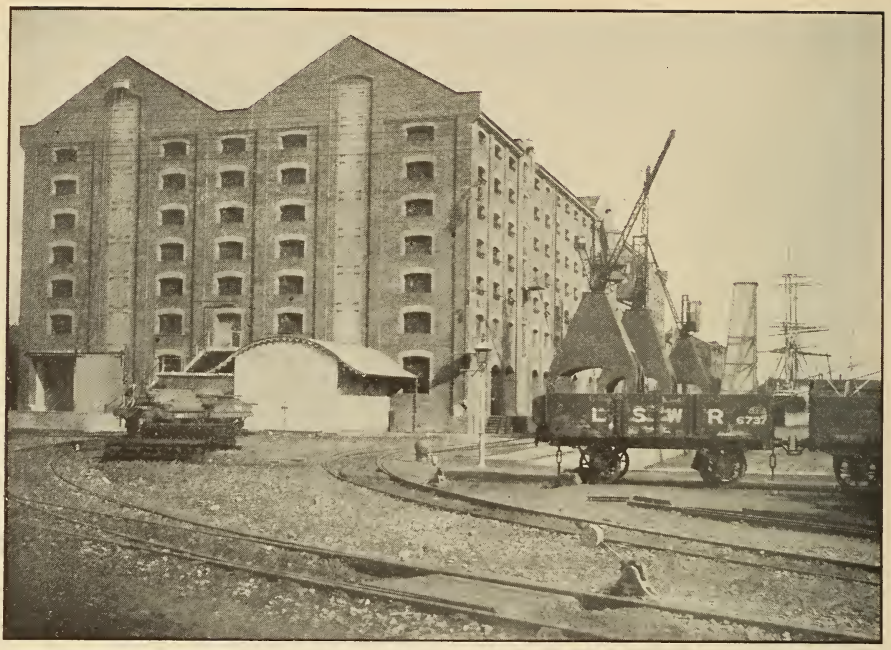
Having traced the growth of the dock undertaking, it is necessary to direct attention to the important subject of equipment. Generally speaking, the passenger and cargo sheds are from 300 feet to 400 feet long by 120 feet to 150 feet wide, all timber built with slated roofs. To facilitate the conveyance by hand truck of the goods loading and discharging from the railway wagons, the floors of most of the sheds have a gradual rise from the quay level to 3 feet 3 inches above the level of the railway lines at the gullet inside the shed. The average width of quay space in front of each shed is about 36 feet, which allows ample working room. These extensive sheds are, for the most part, used as ordinary passenger stations on the arrival or departure of the various ocean liners. Baggage is cleared through H. M. customs with the greatest expedition, and passengers are entrained or detrained, as the case may be, under cover alongside the steamer. Whilst it may be said that the same facilities are afforded at particular berths in certain ports,



EMPRESS DOCK, SOUTHAMPTON



PRINCE OF WALES QUAY, SOUTHAMPTON DOCKS

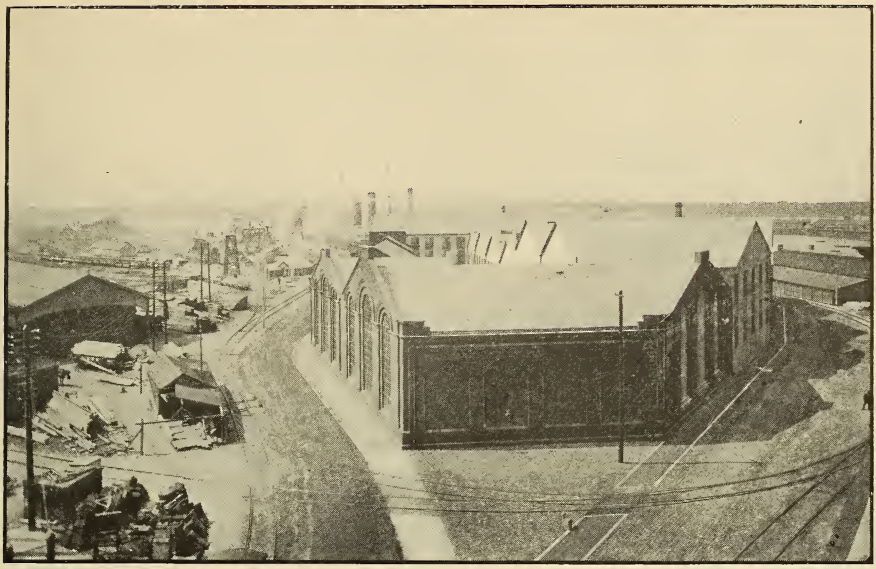


GRAIN WAREHOUSE AND CRANES, SOUTHAMPTON DOCKS

this advantage obtains at all the ocean berths in Southampton, and it accounts for much of the progress which has been witnessed. Owing to the height out of water of the vessels of the White Star Line, whose berths are on the Test Quay, overhead gangways, similar to those in use at Liverpool, have been provided for the use of passengers. By this means ocean passengers walk direct from the vessel's deck into the shed alongside and there enter the special trains awaiting them, whilst their luggage is dealt with by electric baggage conveyors.

At the Prince of Wales Quay may be seen two very fine double-story sheds of the best modern design, the upper floors equipped with electric cranes of a lifting capacity of one ton. The passenger and cargo shed opposite Berth No. 44, erected for the White Star Line at the north-east of the new 16-acre dock, has steel frame sides covered with galvanized iron and a roof of patent felt. It is 700 feet long and 120 feet wide, with two spans of 60 feet and a central row of steel columns 20 feet apart. The foundation rests on concrete piles built on the "Simplex" system. The quay in front of the shed contains three sets of lines, two for railway trucks and a third for the use of the cranes and passenger gantries.

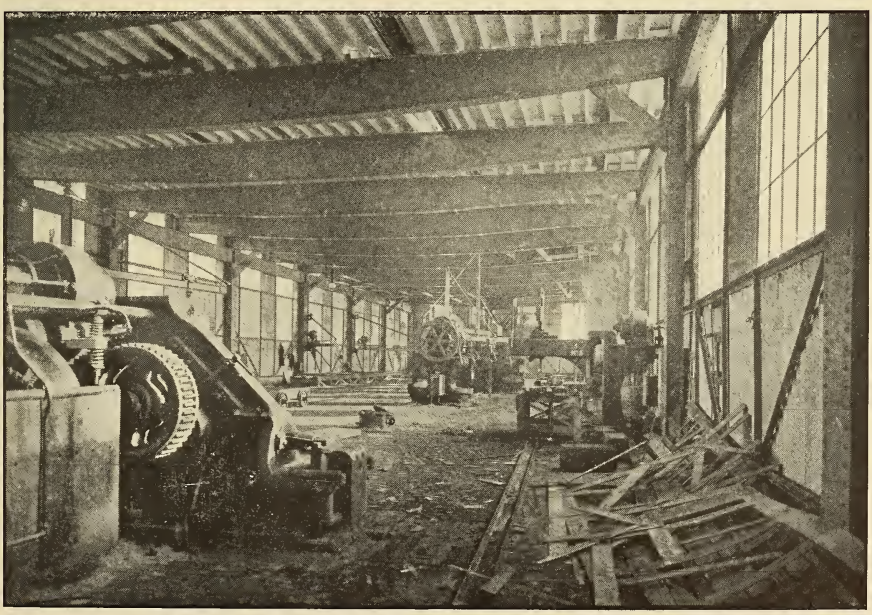
Most of the sheds on the docks have been approved by H. M. customs as transit sheds for the reception of import and export cargoes. With regard to storage accommodation, there is a very fine suite of five warehouses, severally designated "D," "E," "M" and "O," situated on the north and east sides of the Inner Dock, with "N" at the rear of "M." These sheds have an estimated capacity for 2,300,000 bushels of grain. The whole of the warehouses are connected by trunkways, and grain is, by means of a leg conveyor and machinery in the "D" block, conveyed through these ways to any floor in any of the grain warehouses on endless bands, the whole of the machinery for which is driven by electricity. At "O" warehouse, Berth



GENERAL BIRD'S-EYE VIEW OF HARLAND & WOLFF SHOPS AT SOUTHAMPTON WORKS

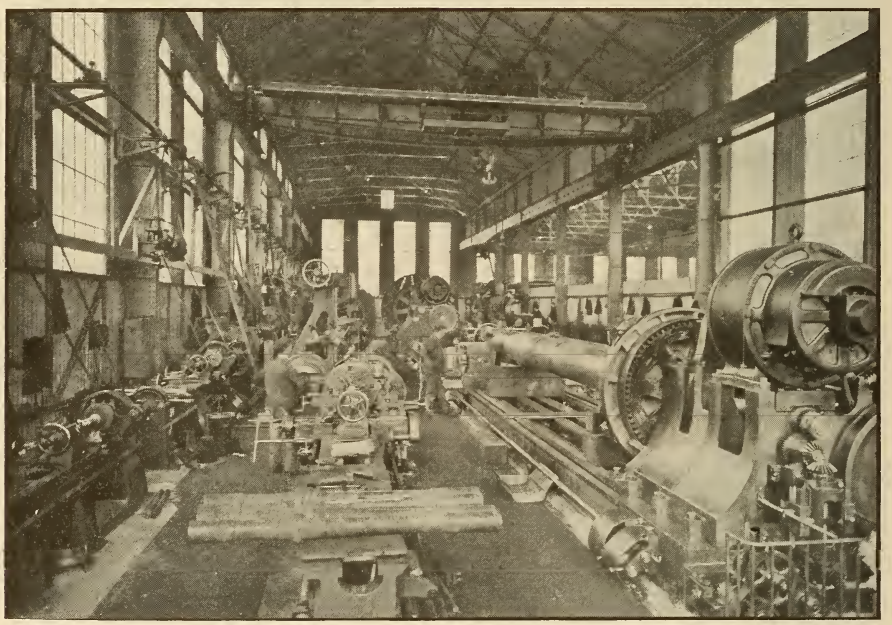
No. 18, Inner Dock, there is an underground band running parallel with the quay edge, which takes its feed through eight mouth-feeding openings arranged through the quay, but this is only used for small vessels.

The cold stores are situated on the Test Quay in a building 400 feet long, 120 feet wide and 50 feet high, resting on ferro-concrete piles, 1,347 in number, and each 43 feet long. The total storage capacity is 1,200,-



IRON SHIPWRIGHTS' PLATING SHED. HARLAND & WOLFF, SOUTHAMPTON WORKS

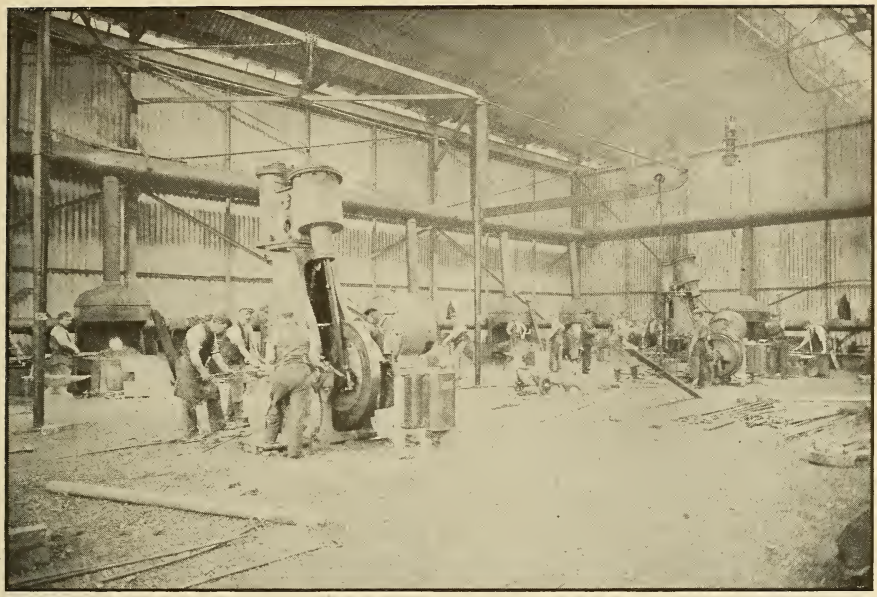
000 cubic feet, which is sufficient for hanging upwards of 15,000 quarters of chilled beef, 155,000 carcasses of sheep, in addition to 500,000 cubic feet of space for the storage of miscellaneous perishable goods. As it is situated on the water side, the largest vessels are able to come alongside and discharge into the cold store at low water. The International Cold Storage & Ice Company, Ltd., have had a great deal to do with the equipment of these cold stores, and estate, more particularly at the Outer Dock, where great quantities of coffee are stored. All the quays are equipped with hydraulic cranes by various makers, possessing lifting capacities from 15 cwt. to 5 tons; some have a lift of 63 feet over a radius of from 42 feet to 46 feet. There are also twelve steam traveling cranes, lifting up to 12 tons, and sheer-legs capable of dealing with loads up to 80 tons. The vault accommodation at the docks has an



FITTING SHOP. HARLAND & WOLFF, SOUTHAMPTON WORKS

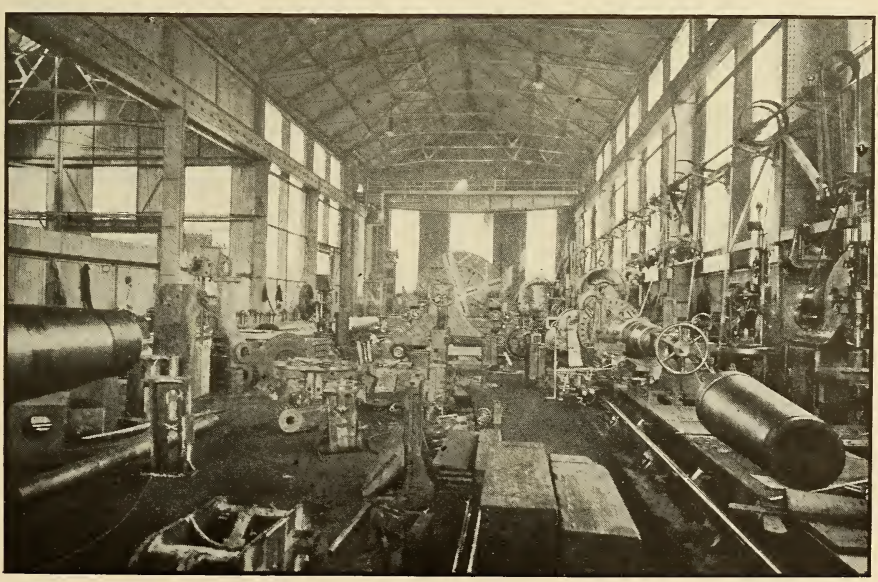
the method of cooling employed is ammonia direct-expansion, three of the five floors being arranged on the gravity air system and one on the air circulation method. Some of the rooms are arranged for cooling, chilling and sharp freezing, in which any necessary temperature can be maintained, whilst other rooms are fitted up with the necessary rails, switches, pulleys, etc., for handling or storing hides or quarters of chilled meat landed from vessels.

Warehouses for storage purposes are well distributed over the dock area of 109,254 square feet, and it is estimated that about 220,000 dozen of champagne could be stored therein. These vaults, as dry as any in the United Kingdom, are lighted by electricity. Before leaving the dock facilities provided by the South Western Railway Company, mention must be made of the means for dealing with colliers bringing coal for the bunkering of the liners and for other purposes. For this trade two large coal docks have been opened on the north of the entrance to the Outer Dock and another on the Woolston



SMITH SHOP. HARLAND & WOLFF, SOUTHAMPTON WORKS

side of the river Itchen. Accommodation has been thus afforded for the floating of as much as 14,000 tons of coal at one time, whilst the lighterage capacity is 20,000 tons and engaged at present wholly in bunkering liners. The coal is discharged from colliers by four electric cranes by Appleby's, Ltd., fitted with Priestman grabs, with a shipment rate of

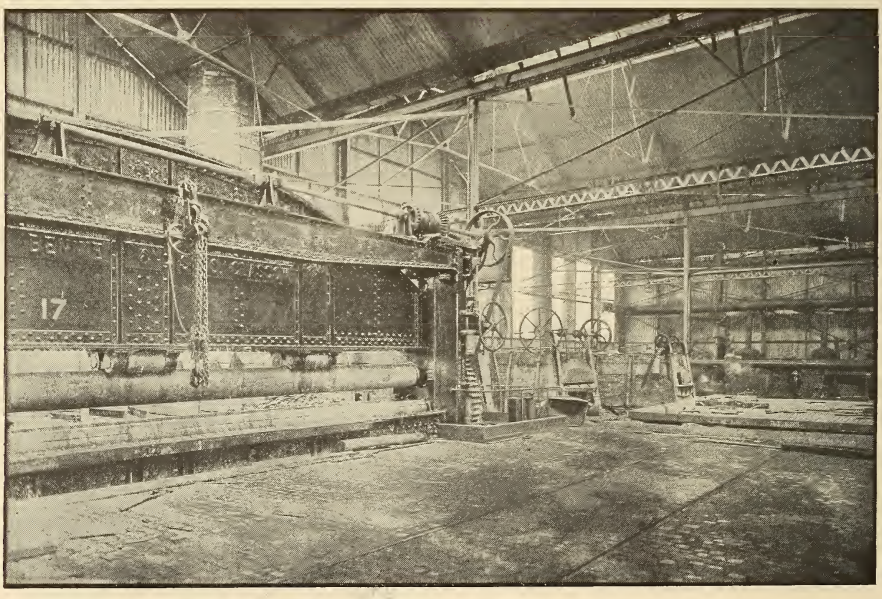


TURNING AND MACHINE SHOP, SOUTHAMPTON WORKS

75 tons per hour each. The electricity for lighting the whole of the docks, railway stations and buildings and for power purposes is generated at the company's station near Trafalgar Dock. For outdoor work, lamps of 2,000 candle-power are used, whilst inside the sheds are smaller lamps of 500 candle-power, and flaming arc lamps of 4,000 candle-power illuminate the sheds of the new 16-acre dock. The present plant is capable of producing 40,000 units in twenty-four hours, and, in addition to supplying its own needs, the company supplies electricity to the shipping companies and ship repairers having works, etc., at the docks.

The trade ramifications of Southampton are world-wide and comprise all commodities; and as it is the chief port for supplying London markets, it is unnecessary to detail the various goods dealt with. The marshaling sidings are situated near the docks, where there are 34½ miles of railway lines, and six weigh bridges have been provided to facilitate the necessary traffic operations. There is also a complete telephonic installation, open day and night, and the railway company owns its own dredging plant and all necessary appliances, and provides its own police. In addition to these services, an excellent service of steamships maintains a cross-Channel service with France and the Channel Islands, whilst a flourishing branch of St. John's Ambulance Brigade is in existence at the docks.

Although the London & South Western Railway are the dock owners, it is the Southampton Harbour Board which has jurisdiction over the harbour and town quays, and whilst the two bodies are entirely independent of each other, they work together for the good of the port; and thus one finds the South Western Railway running trains along the Royal Pier and in every way assisting to make the port popular with vessels landing passengers, mails and specie, etc. A plan showing the Board's property is reproduced by permission of Mr. J. E. Pailthorpe, the courteous clerk to the Board, and excellent warehousing accommodation is provided, together with ade-



FURNACES, FRAME BLOCKS, PLATERS, ROLLS, ETC. HARLAND & WOLFF, SOUTHAMPTON WORKS

OUTFIT DEPARTMENT, UPHOLSTERERS' AND POLISHING SHOP, SOUTHAMPTON WORKS

quate facilities for loading and discharging cargoes. The total estimated value of the Board's plant is £200,000, which is improved as occasion requires. At the present time attention is being concentrated on the provision of a deep-water channel, 35 feet, at L. W. O. S. T., and this is being done by the Tilbury Contracting & Dredging Company at a cost of £39,000. A portion of the Town Quay is also being rebuilt by Mr. Henry Lovatt, of Darlington, at a cost of £15,000. Some work on the Town Quay is also being carried out by the Board's own engineering department at a cost of £2,000. The revenue of the Board is, of course, derived from dues on shipping going into or out of the port, and also on all goods landed or shipped at the quays of the Board. There is one steam launch, built by Phillips, of Dartmouth, in 1904, which is the "fleet" of the Board, which is of much use in attending the lights of the Harbour Board in the Itchen, etc.

Any description of the port of Southampton would be incomplete without reference to the ship repairing facilities at the port. Immediately in the vicinity of the Trafalgar Dock is a fine range of buildings erected for Messrs. Harland & Wolff, with which we shall hope to deal at a later date. Messrs. Day, Summers & Co. have branch works, and Messrs. J. I. Thornycroft's works are on the Woolston side of the Itchen. In addition to these firms, there are numbers of others, who can and will supply every need of a vessel, and it is a high tribute to the facilities of Southampton that, after using Liverpool as a terminal port for such a number of years, both the White Star and Cunard Lines make it the home of some of their best boats. Of course, there are reasons and reasons for this change, which it is not policy to divulge, but those who do know have wondered why those lines remained on the Mersey so long. However, it is not our intention to pit one port against the other. The coming of the White

Star to Southampton sounded the first knell in the decline of Liverpool, and, despite what other ports may say, the facilities of Southampton for dealing with passengers and goods are unrivaled in the British Isles. Despatch, cheapness and handiness of access are all a shipper asks, and these Southampton provides with no ungenerous hand. The future of Southampton is particularly bright, and if only the same policy is pursued in the future as has been carried out by railway company, Harbour Board and shippers alike, she will not only retain but augment her present success, and that is the desideratum of all, whatever they be.

REMARKABLE LOCOMOTIVES OF 1911

By J. F. Gairns

DURING 1911 a considerable number of locomotive designs of more or less interest made their appearance on the principal railways of various countries. But there were only a few developments of an epoch-making character, the tendency being, on the whole, to progress on lines already prepared by previous practice, substantially novel features being exhibited only by three or four designs. Adopting the method followed in the article published in this magazine in June, 1911, it will be advisable to deal with those designs which include such special features before proceeding to a review of engines which are interesting mainly as developments of practice of earlier years.

Three-cylinder, non-compound locomotives are not novel, for on the Great Central and North Eastern Railways in England, and here and there on railways in other countries, such engines are, or have been, in use. But, except for an experimental conversion on the Great Central, the writer is not aware of any intended expressly for heavy express traffic, most of the three-cylinder simple engines being of the tank variety. Therefore, Mr. Vincent Raven's three-cylinder "Atlantics" for the English North Eastern Railway must rank as of special interest, more especially as they also include the unique feature that the three cylinders, together with their piston valve casings, are formed in one huge casting. There are actually two series of these engines, one class using saturated steam, while the others are fitted with Schmidt superheaters. Most illustrations which have appeared in the railway and engineering press depict the non-superheater variety, but Fig. 1 shows an engine of the superheater class. All have been constructed by the North British Locomotive Company, Ltd. The view indicates the interesting character of the design as a whole, apart from the features referred to, and although there are similarities to the two-cylinder "Atlantics" already in service, and more particularly to the four-cylinder 4—4—2 Smith compounds, the new classes rank as important developments in practice. During the summer these engines were continually engaged on the hardest duties, and it is understood that all have done splendidly, though the honours are with the superheater class.

Superheater development will be considered in detail at a later stage, but reference may be made here to the initial appearance of the Robinson apparatus in conjunction with one of the more or less novel designs requiring description at this stage. Fig. 2 shows one of the new engines, designed by Mr. J. G. Robinson, chief mechanical engineer of the Great Central Railway. These are the first of the 2—8—0 class on this line, though derived from 0—8—0 engines already in use; but, as stated, their principal interest is that they have Mr. Robinson's superheater. This apparatus is constructed on the same lines as the well-known Schmidt design, with double-looped steam tubes extending from the smoke-box header into large fire tubes in the boiler, and is intended for obtaining high superheat. There are, however, constructional modifications relating to the header, the means of attaching the tubes thereto and certain other details. Several railways are stated to be experiment-

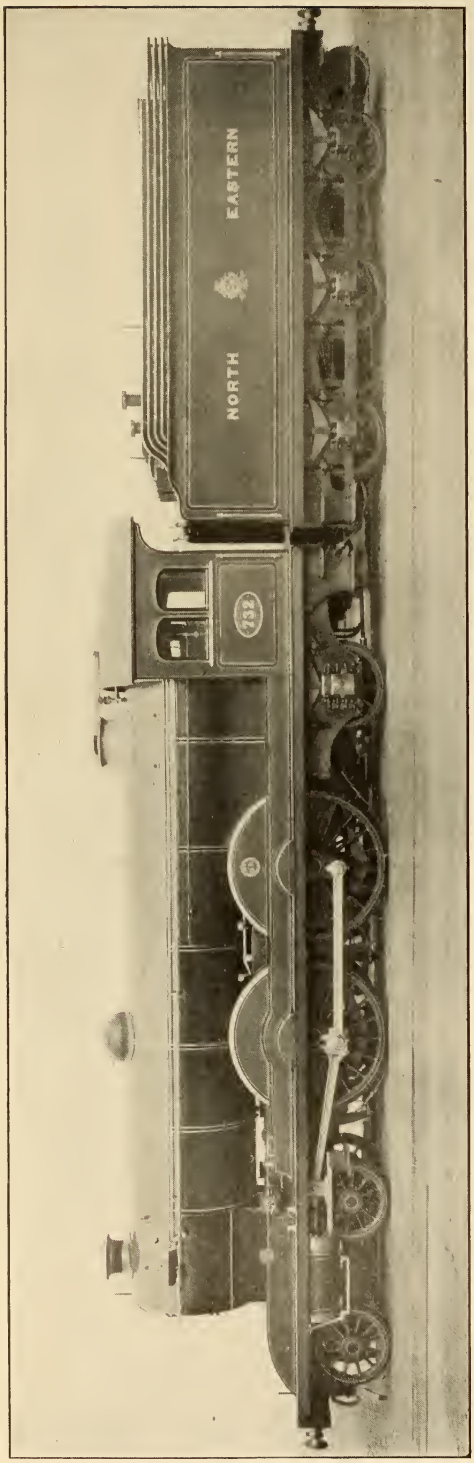


FIG 1.—THREE-CYLINDER SIMPLE EXPRESS LOCOMOTIVE WITH SCHMIDT SUPERHEATER. NORTH EASTERN RAILWAY. DESIGNED BY VINCENT L. RAVEN. CONSTRUCTED BY THE NORTH BRITISH LOCOMOTIVE CO., LTD.

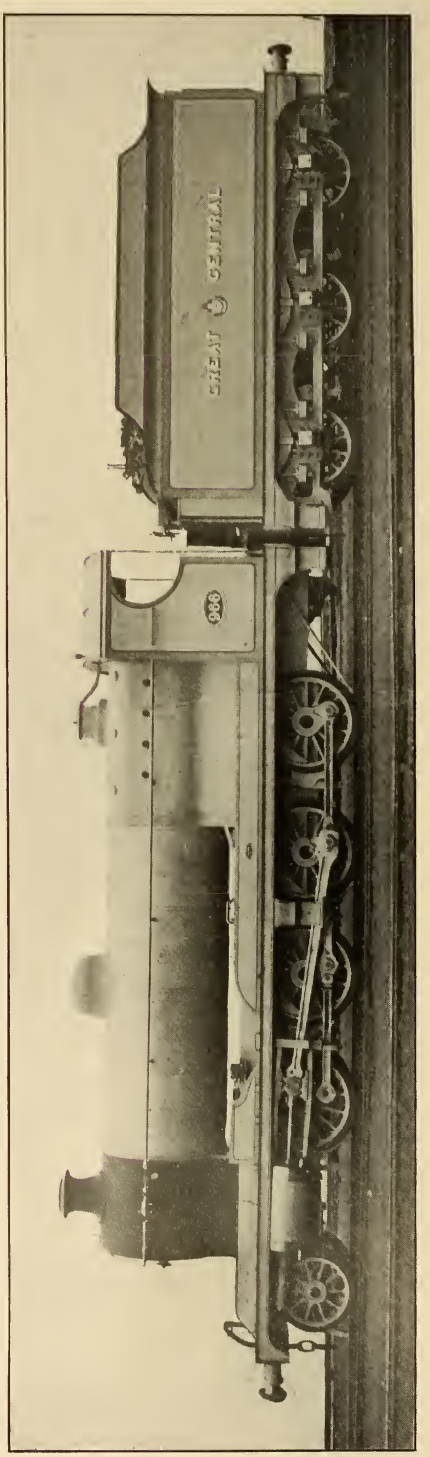


FIG. 2.—MINERAL LOCOMOTIVE OF THE 2-8-0 TYPE WITH ROBINSON SUPERHEATER. GREAT CENTRAL RAILWAY. DESIGNED BY I. G. ROBINSON

ing with this apparatus. It is yet too early to speak of the results obtained or the satisfaction given under every-day working conditions and when questions of repair and maintenance arise.

In last year's article reference was made to some remarkable 4—6—4 express locomotives under construction for the Northern Railway of France. These have now been completed, and Fig. 3 illustrates one of them. Two engines have been constructed for comparative trial, No. 3,101 (illustrated) having a large Belpaire firebox, while No. 3,102, which is otherwise similar, has a water-tube firebox of the type described last year in reference to a 4—4—4 locomotive. These are the first engines known to the writer to have the 4—6—4 wheel arrangement, and a study of the dimensions, given in tabular form at the end of this article, with those of other locomotives considered, indicates how exceptionally large and powerful they are. The trailing bogie is, of course, necessitated by the huge dimensions of the firebox, and in consequence of the large diameter of the low-pressure cylinders they are arranged in a peculiar manner between the frames. One cylinder is placed in advance of the other so that it overlaps the diameter thereof, though clear of its piston rod. The respective connecting and piston rods are, therefore, of different lengths; but this fact is taken into account in dealing with the mechanical problems involved. A large Schmidt superheater is fitted, and in conjunction with the high pressure, the extreme dimensions, the inclusion of compounding, and several other features, one is justified in expecting notable results from experience and tests carried out with these two engines. It is understood, however, that they are virtually experimental machines, and at present will appear in regular service only in connection with trials and test runs.

For many years Herr von Gölsdorf

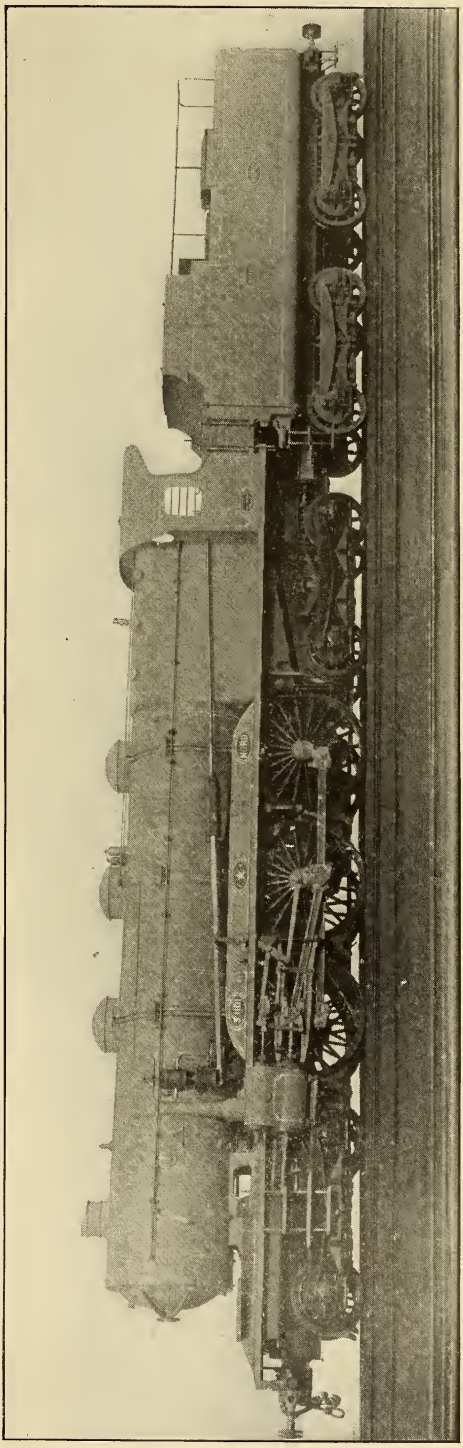


FIG. 3.—COMPOUND SUPERHEATER LOCOMOTIVE OF THE 4-6-4 TYPE. NORTHERN RAILWAY OF FRANCE. CONSTRUCTED AT THE RAILWAY WORKS FOR SPECIAL PURPOSES

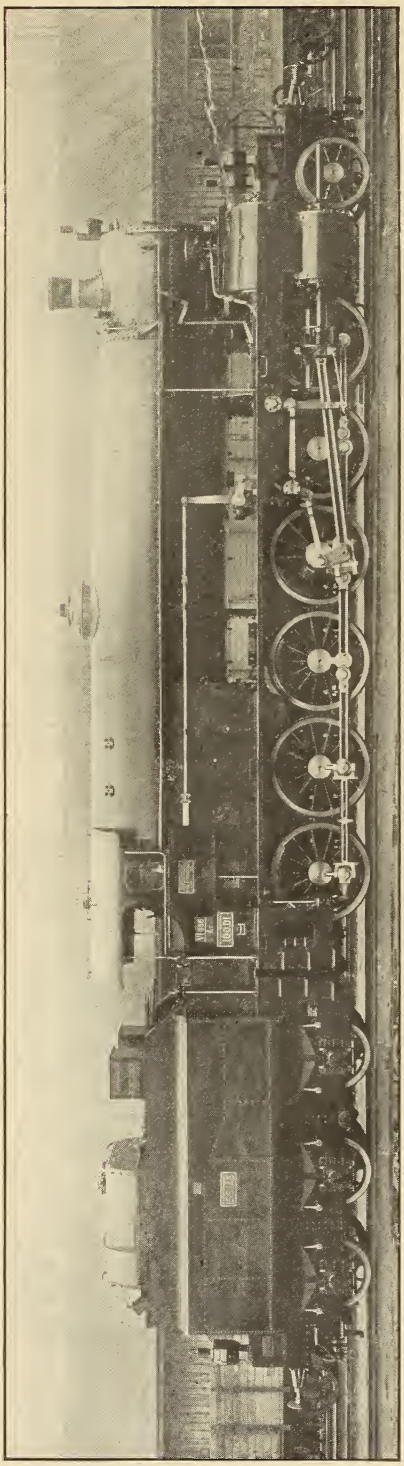


FIG. 4.—FOUR-CYLINDER COMPOUND SUPERHEATER LOCOMOTIVE OF THE 2-12-0 TYPE FOR MOUNTAIN SERVICE. AUSTRIAN STATE RAILWAYS

dorf, chief engineer of the Austrian State Railway Administration, has been responsible for numerous notable locomotive designs; but the new class illustrated in Fig. 4 may be considered his *magnum opus* for the time being. They are intended for working heavy trains, both goods and passenger, over the extreme mountain grades, such as 1 in 35 and 40, which occur on certain trans-Continental routes; but even for such duties the fact that they have twelve coupled wheels, are four-cylinder compounds, and are fitted with a Schmidt superheater, renders them of special interest. In fact, they are the only twelve coupled engines known to the writer in modern days, though American practice produced a few many years ago. To facilitate the passage of very difficult curves the two rear coupling rod sections have pivotal joints, and the second, fifth and sixth coupled axles have lateral play, while the driving wheels are flangeless. Although the usual maximum speed is about 37 miles an hour, it is understood that a rate of 57 miles an hour has been safely reached. An important feature is the low axle load, the heaviest being 13 tons 12 cwt.

America is now almost the exclusive home of the Mallet type articulated locomotive, especially on a large scale, and several interesting designs of this class will require reference in due course. But the locomotive illustrated in Fig. 5 is peculiarly notable, in that it provides the only instance of the provision of twenty driving wheels in one machine. The origin of the class is somewhat strange. Some ten years or so ago a series of enormous 2—10—2 tandem compound engines were placed in service by the Atchison, Topeka & Santa Fé Railroad. These were then the largest locomotives in the world, and represented about the extreme possible developments under non-articulated conditions. They have now been utilized to produce the new design by fitting

a fresh boiler with front extension containing superheater, reheater and feed-water heater, removing the leading wheels and the high pressure cylinders and attaching an articulated frame with another set of wheels, high-pressure cylinders, pony truck and other details. The new parts were supplied by The Baldwin Locomotive Works, and the result is the production of a design that is by far the largest in the world, and which is unique and likely to remain so for some years. In service these engines have done marvelous work on the mountainous sections, and it is understood that they have abundantly justified themselves in every way.

The foregoing exhausts the more or less novel designs associated with 1911 known to the writer; but a large selection of interesting designs, including features for which precedents could be furnished, is available for consideration. In fact, as will be seen, it is somewhat difficult to draw the line between what is fresh and what is of special interest as representing progress in locomotive engineering. Further reference will, however, be made on the basis of wheel arrangements, six-coupled, eight-coupled and articulated; but before dealing with specific locomotives it will be advisable to devote some space to the important subject of superheater development, as so many of the designs to be reviewed include this feature.

The Schmidt superheater is still by far the most important factor in the world's practice, and as regards other designs there is a tendency to reduce the number of competitors. In Great Britain the Swindon apparatus is largely used, but almost exclusively on the Great Western Railway, where Mr. Churchward now fits it to nearly all new engines, together with many older ones requiring new boilers or extensive rebuilding. Two other railways have equipped engines experimentally therewith; otherwise, the total of about 300 engines is provided only

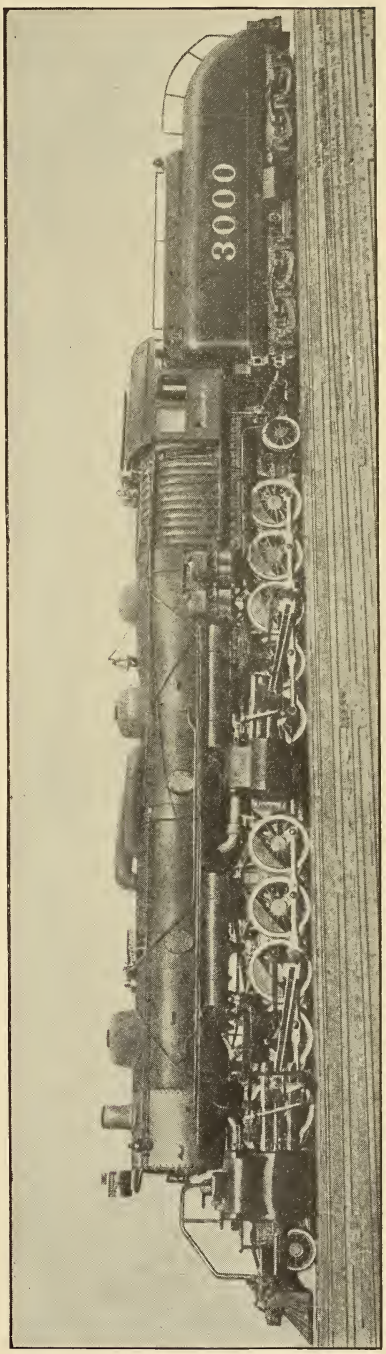


FIG. 5.—ARTICULATED LOCOMOTIVE OF THE 2-10-10-2 TYPE. ATCHISON, TOPEKA & SANTA FÉ RAILWAY. REBUILT BY THE BALDWIN LOCOMOTIVE WORKS

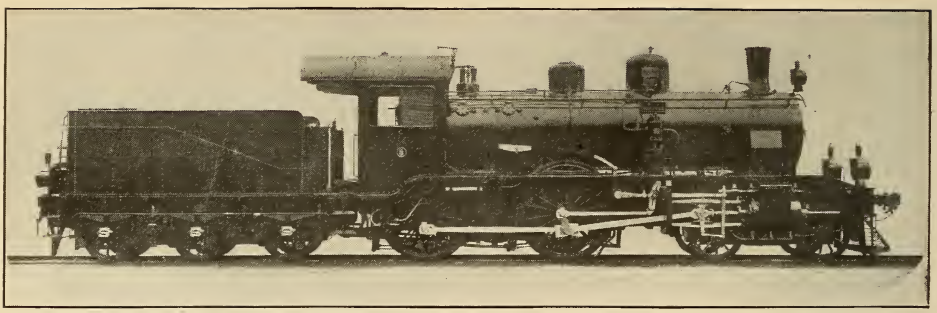


FIG. 6.—PASSENGER LOCOMOTIVE OF THE 4-4-0 TYPE FOR THE CHEKIANG RAILWAY, CHINA

on the Great Western. The Phœnix superheater, of smoke-box type, has been fitted to a few engines on British railways, while the programme announced in connection with the Robinson apparatus already referred to indicates the equipment of several locomotives on the Great Central and other railways. But on a wider basis superheater progress in Great Britain is associated principally with the Schmidt design. In the case of the latter about 400 engines are at work or under construction. It may be mentioned that the Swindon construction is now owned by the Schmidt Company, while the Robinson design is still in its trial stages, only a few installations being yet at work. Nearly all British locomotive building for other countries involves the use of the Schmidt superheater, and throughout the rest of the world, except North America, the pioneer high superheat design is virtually the only one employed. Even in North America the Schmidt superheater is principally in evidence, some 1,700 engines being so equipped in the United States alone. In Canada the Vaughan-Horsey construction, now owned by the Locomotive Superheater Company, of New York (the American Schmidt firm), is somewhat extensively used, and occasionally on United States railways. The Baldwin and Jacobs superheaters are used for a number of locomotives in the United States, the latter mostly for large articulated engines having removable front extensions. But it is probably correct to state that in the aggregate the Schmidt superheater controls the world's practice to the extent of about four to one; and the present total number of equipments is more than 12,000, nearly 300 separate railways or railway administrations being represented.

The following table, showing the diversity and extent of employment of the Schmidt apparatus in various countries, will be of interest:

Germany (Prussia 3,482)	4,026
United States	1,634
Austria	636
Russia	674
Belgium	532
Italy	472
France	1,117
Great Britain	403
British Colonies	629
Sweden	301
Switzerland	174
Argentine	127
Spain	117
Holland	90
Denmark	79
Japan	73
Dutch Colonies	73
Turkey	71
Roumania	68
Norway	46
Brazil	40

and smaller totals in Bulgaria, Finland, Greece, Luxembourg, Portugal, Hungary, Egypt, Chili, Congo State, French Colonies, Syria and Uruguay.

Having thus cleared the way for detailed consideration of specific designs, reference will now be made to a selection of interesting locomotives constructed during 1911. As regards four-coupled classes, the North Eastern three-cylinder "Atlantics" have already received attention, and only one other design calls for reference in the tender-engine section. Fig. 6

illustrates a 4—4—0 engine constructed by the Berlin Engineering Works for the Chekiang Railway of China. This is hardly distinctive, as no special features are included, but is an example of modern practice for little known railways where demands are not as yet severe, though up-to-date characteristics may be observed in conjunction with adaptation to local conditions by the provision of sun-blinds to the cab and in other ways.

On the English North Staffordshire Railway Mr. J. H. Adams has introduced an interesting class of 4—4—2 tank engines for express traffic, these being the first of this type on the line, though it is one eminently suited for working largely by tank engines. A Schmidt superheater is fitted, and the review of dimensions will indicate the advanced character of the design as a whole. On other British lines it is only necessary to mention new "Atlantics" with Schmidt superheaters on the Great Northern and London Brighton and South Coast Railways, and without superheaters on the North British; in conjunction with new superheater 4—4—0 locomotives on the Great Northern of England and the Great Northern of Ireland. The latter classes have the Schmidt apparatus, except those on the Great Northern, where the Phœnix design is adopted. The Great Northern of Ireland is having built five 0—6—0 and five 4—4—0 locomotives equipped with Schmidt superheaters. In the case of the Midland engines referred to a special damper controlling mechanism is fitted, by which the benefits of superheat may be obtained while the engine is standing and during shunting operations. For this purpose a valve is provided by which the driver can hold the superheater dampers open irrespective of the regulator, when desired, though in the event of the blower being used beyond a predetermined degree the dampers are automatically closed.

As regards the 0—6—0 type, little need be said, as it is not much used outside Great Britain. New superheater designs of this character have, however, made their appearance in the United Kingdom on the Great Northern (Schmidt), Midland (Schmidt), Great Northern of Ireland (Phœnix) and Hull & Barnsley (Phœnix) Railways.

Two examples of the 2—6—0 type may be refered to. On the English Great Western Railway 2—6—0 goods engines have been used for some years, though the type is unusual elsewhere; but the new class, just introduced by Mr. G. T. Churchward, have little in common with

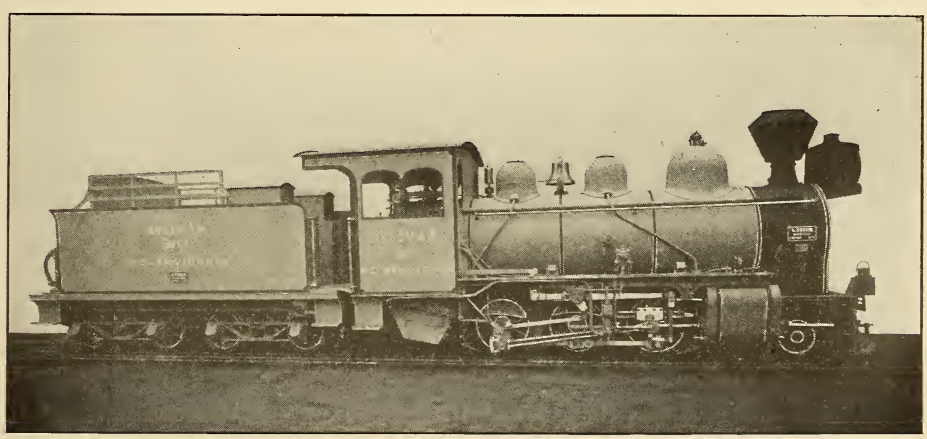


FIG. 7.—NARROW GAUGE LOCOMOTIVE OF THE 2-6-0 TYPE, WITH SCHMIDT SUPERHEATER. ANTIOQUIA RAILWAY, COLOMBIA. BUILT BY A. BORSIG, BERLIN

them. The older ones have inside cylinders and outside frames, whereas the class just placed in service have outside cylinders and inside frames, while many of the dimensions differ considerably. The new series are intended more especially for working express goods trains, excursions and slow passenger trains on the main lines, thus amplifying the small wheeled 4—4—0 locomotives generally employed for such traffic. They are very similar to the large 2—6—2 tank engines in service. The Swindon superheater is fitted.

ern, London & South Western, London & North Western and Glasgow & South Western.

For several years the Great Eastern has had to deal with extreme loads, and the work done by many of the 4—4—0 engines is remarkable, but increased engine power has now become an absolute necessity. In order to meet requirements, Mr. S. Dewar Holden has, therefore, placed in service five engines of the class illustrated by Fig. 8. It must, however, be remarked that they are, for the 4—6—0 type, relatively small

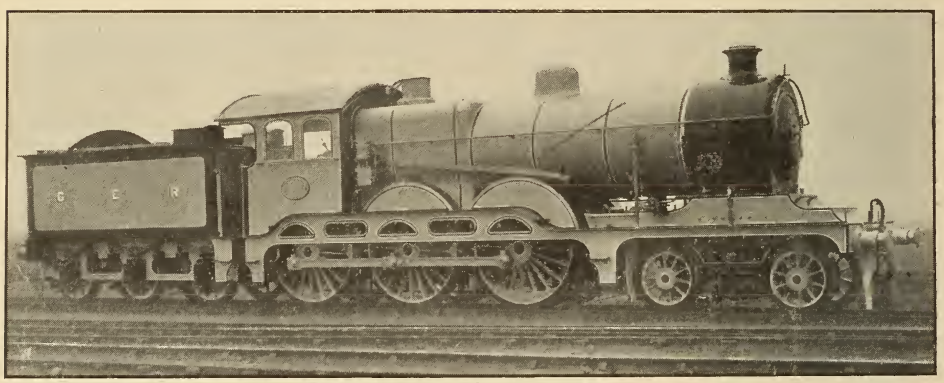


FIG. 8.—SUPERHEATER LOCOMOTIVE OF 4-6-0 TYPE. GREAT EASTERN RAILWAY. DESIGNED BY S. DEWAR HOLDEN

Fig. 7 illustrates an altogether different design, constructed by the well-known German firm of A. Borsig for the Antioquia Railway, of Colombia, South America. The gauge is only 3 feet, but in several ways the design is an advanced one, the equipment including a Schmidt superheater, mechanical lubricators and other features which can be observed from the photographic reproduction.

It is now necessary to consider the 4—6—0 type, which is mainly favoured for heavy fast express traffic in Great Britain, and is largely used in other countries, though tending to be displaced by the 4—6—2 class where circumstances permit. More or less novel designs of this character appeared during 1911 on the following British railways: Great Eastmachines, as it was necessary to keep weights within limits; but as Schmidt superheaters are employed and the cylinders have the long stroke—for Great Britain—of 28 inches, while the standard pressure of 180 pounds is maintained with 20-inch cylinders, they represent a big advance upon the 4—4—0 engines which have only been available hitherto. The Belpaire firebox extends over both the trailing and intermediate coupled axles, the front portion of the grate being inclined. Piston valves, Wakefield lubricators and other fittings complete the equipment which is closely in accordance with the practice advocated by the Schmidt Superheating Company. Double safety valves are arranged on the boiler, this feature being now standard on the Great Eastern.

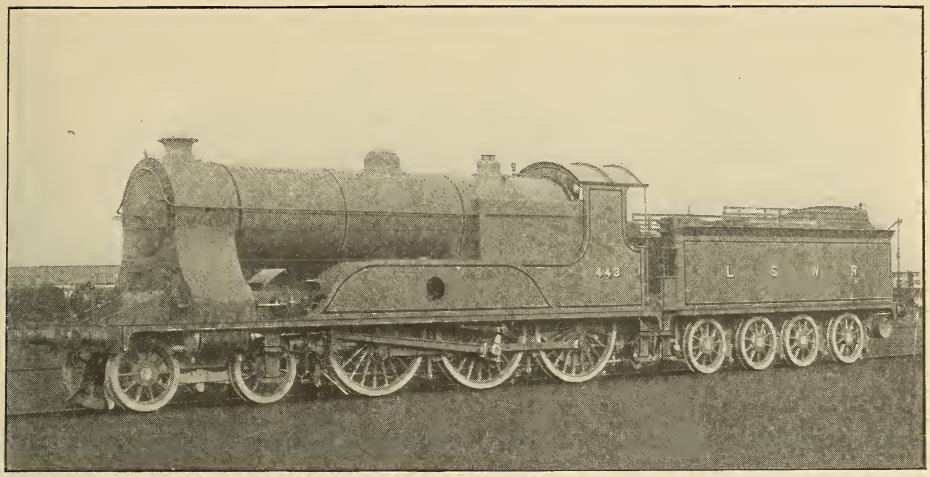


FIG. 9.—FOUR-CYLINDER 4-6-0 EXPRESS LOCOMOTIVE FOR THE LONDON & SOUTH WESTERN RAILWAY, DESIGNED BY DUGALD DRUMMOND

For several years large four-cylinder 4—6—0 engines have been at work on the London & South Western Railway, but as these were designed for the severely graded West of England main line the coupled wheels were only 6 feet in diameter. During the early part of 1911 Mr. Dugald Drummond constructed new engines of the same class, but having piston valves and Walschaert valve gear; and these were followed by a further series having coupled wheels 6 feet 6 inches in diameter, and intended more especially for the proposed accelerated Bournemouth services. One of these notable engines is illustrated in Fig. 9, most of the special features being indicated by the reproduction. For

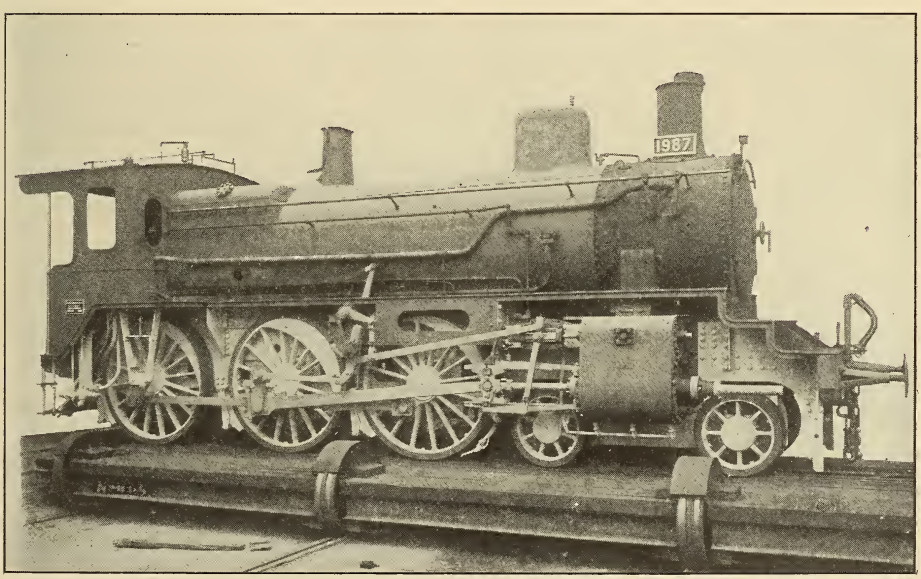


FIG. 10.—LOCOMOTIVE OF THE 4-6-0 TYPE WITH SCHMIDT SUPERHEATER, FOR THE NORTHERN RAILWAY OF SPAIN. CONSTRUCTED BY HANOVER ENGINEERING CO.

controlling the valves of the inside cylinders which actuate the leading coupled axle rocking shafts are used. The firebox contains Mr. Drummond's well-known firebox water tubes. During the year the proposed acceleration of the Bournemouth trains was carried out, and these engines have done splendid work thereon, several notable records having come under the writer's personal observation. A new series of similar engines are now appearing, having a few modifications, also including a smokebox superheater of Mr. Drummond's design. New 4—4—0 engines including the same features are also being introduced.

On the London & North Western the new 4—6—0 engines represent mainly the application of the Schmidt superheater to the standard design already in use. A new 4—6—0 class with four simple cylinders, Schmidt superheater and other features is now under construction, and these will, it is understood, constitute one of the most remarkable designs in Great Britain. On the Glasgow & South Western, too, the new 4—6—0 engines are adaptations of an existing class, with the Schmidt superheater; but the result has been to produce a remarkable design. One of these engines has also been fitted with a feed-water heater, the drum of which is placed above the boiler. This, in combination with a large Weir feed pump on the main frame, gives the engine a peculiar appearance.

Outside Great Britain the 4—6—0 type is not now very extensively used, but two examples of recent practice with this wheel arrangement may be referred to. Fig. 10 illustrates an interesting four-cylinder compound engine belonging to the Northern Railway of Spain, constructed by the Hanover Engineering Works, of Linden-Hanover, Germany. The compound system employed is that introduced by the late Herr von Borries, but in addition a Schmidt superheater is employed. The design incorporates several notable features; but as more or less similar locomotives have been used for several years, further reference is hardly necessary. It should be noted that the gauge of the Spanish main lines is 5 feet 6 inches.

The locomotive represented by Fig. 11 is an example of German practice by the firm of A. Borsig for South America, and is one of several supplied to the Argentine Northern Railway for use on metre gauge lines. For such railways the engines are of considerable size and include up-to-date features, such as Belpaire

FIG. 11.—LOCOMOTIVE OF THE 4-6-0 TYPE FOR THE ARGENTINE NORTHERN RAILWAY. A. BORSIG, BERLIN

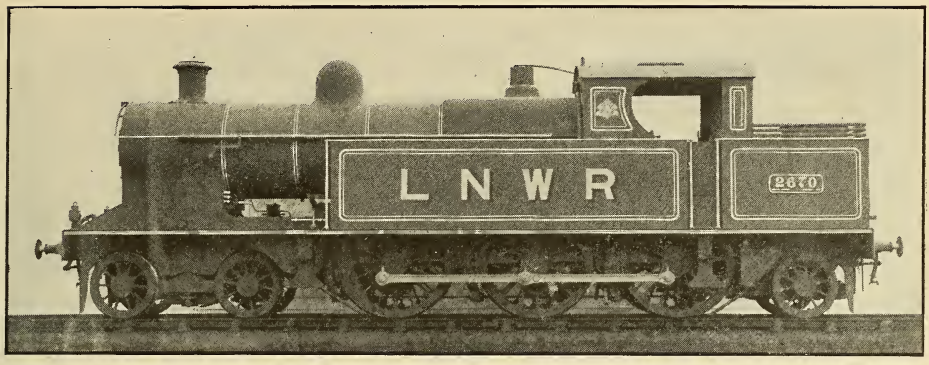


FIG. 12.—TANK ENGINE OF THE 4-6-2 TYPE, WITH SCHMIDT SUPERHEATER. LONDON & NORTH WESTERN RAILWAY. DESIGNED BY C. J. BOWEN COOKE

firebox, Walschaert valve gear, etc. They indicate also the peculiar neatness of outline which has become characteristic of this particular German firm during late years, the suggestion of British practice being very strong.

At this stage it will be convenient to consider two interesting 4—6—2 tank engines introduced on British railways, by reason of the fact that such locomotives represent virtually the adaptation of the 4—6—0 type in tank engine form, the trailing wheels being provided only for supporting the bunker. On the London & North Western Railway early in 1911 Mr. C. J. Bowen Cooke introduced a series of these tank engines for secondary main line traffic and for working on principal branches where limitations of axle loading prohibited the employment of certain of the more powerful classes of other types. Two series of these engines were constructed, one with a feed-water heater and the other with Schmidt superheaters. An engine of the latter set is shown in Fig. 12. As will be seen, a Belpaire firebox is fitted, this being an unusual practice on this line, and the dimensions indicate that considerable load-hauling capabilities are associated with speedi-

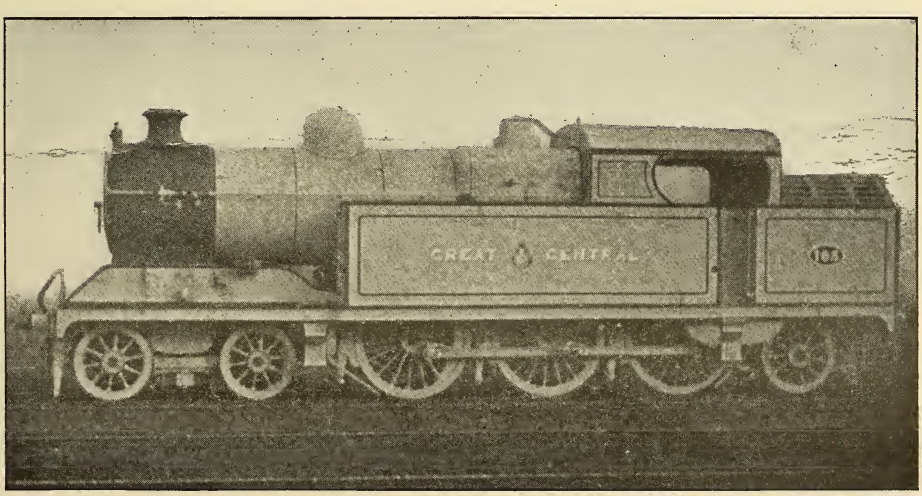


FIG. 13.—NEW TANK ENGINE FITTED WITH SCHMIDT SUPERHEATER. GREAT CENTRAL RAILWAY DESIGNED BY J. G. ROBINSON

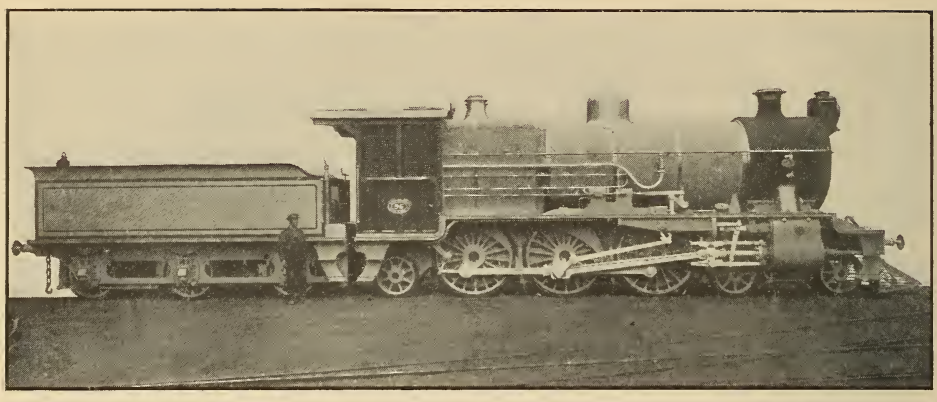


FIG. 14.—SUPERHEATER LOCOMOTIVE OF THE 4-6-2 TYPE, IN USE ON THE SAO PAULO RAILWAY OF BRAZIL. BUILT BY THE NORTH BRITISH LOCOMOTIVE CO., LTD.

ness. Pick-up mechanism for taking water from track troughs when traveling in either direction is provided.

The engines illustrated by Fig. 13 were designed by Mr. J. G. Robinson for the purpose of working heavy and fast business express trains in the London suburban area of the Great Central Railway, and for about twelve months they have performed such duties with great satisfaction. A Schmidt superheater is employed, and pressure is reduced to 165 pounds per square inch; but it is understood that some of them have been working with only 145 pounds per square inch without difficulty.

Outside Great Britain the 4—6—2 type tends to become the standard for heavy and fast express traffic, so that a comprehensive selection of interesting designs of this class could be considered; but space will only allow of three examples being now included, one constructed in Great Britain for use in South America, another used on the Italian State Railways, and the third being representative of a number of designs introduced in the United States. Fig. 14 shows the South American engine referred to, constructed by the North British Locomotive Company in Glasgow for the Sao Paulo Railway of Brazil. This design may be said to represent the highest development at present used in South America in

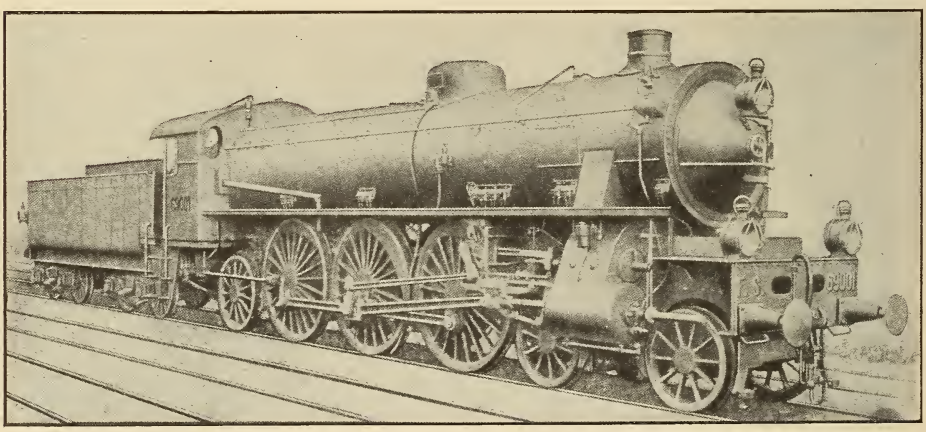


FIG. 15.—FOUR-CYLINDER SIMPLE PACIFIC LOCOMOTIVE WITH SCHMIDT SUPERHEATER. ITALIAN STATE RAILWAYS. CONSTRUCTED BY ERNESTO BREDA, OF MILAN

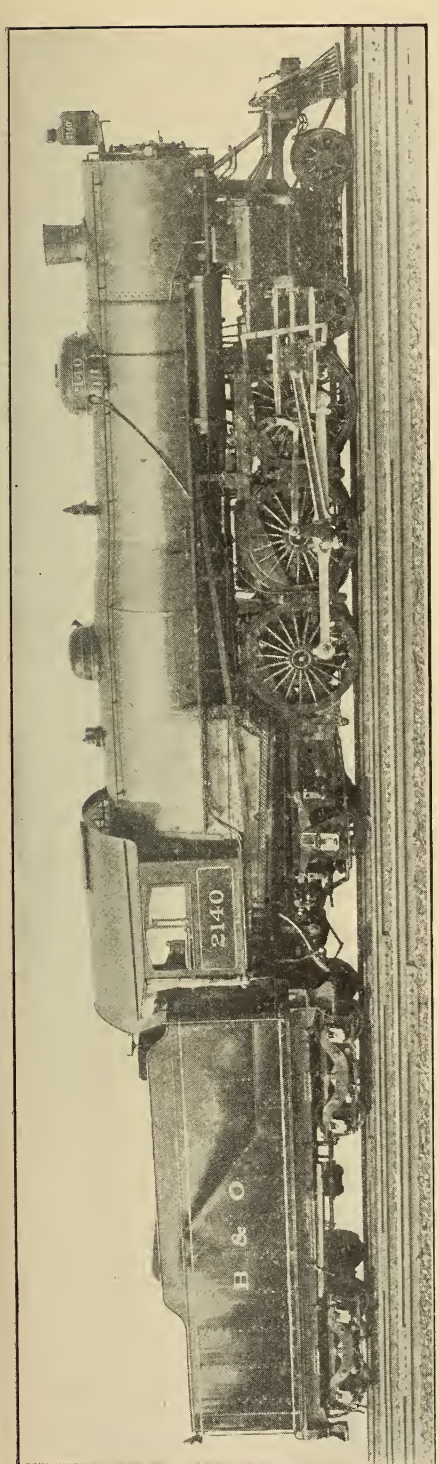


FIG. 16.—EXPRESS LOCOMOTIVE OF THE 4-6-2 TYPE. BALTIMORE & OHIO RAILROAD. THE BALDWIN LOCOMOTIVE WORKS

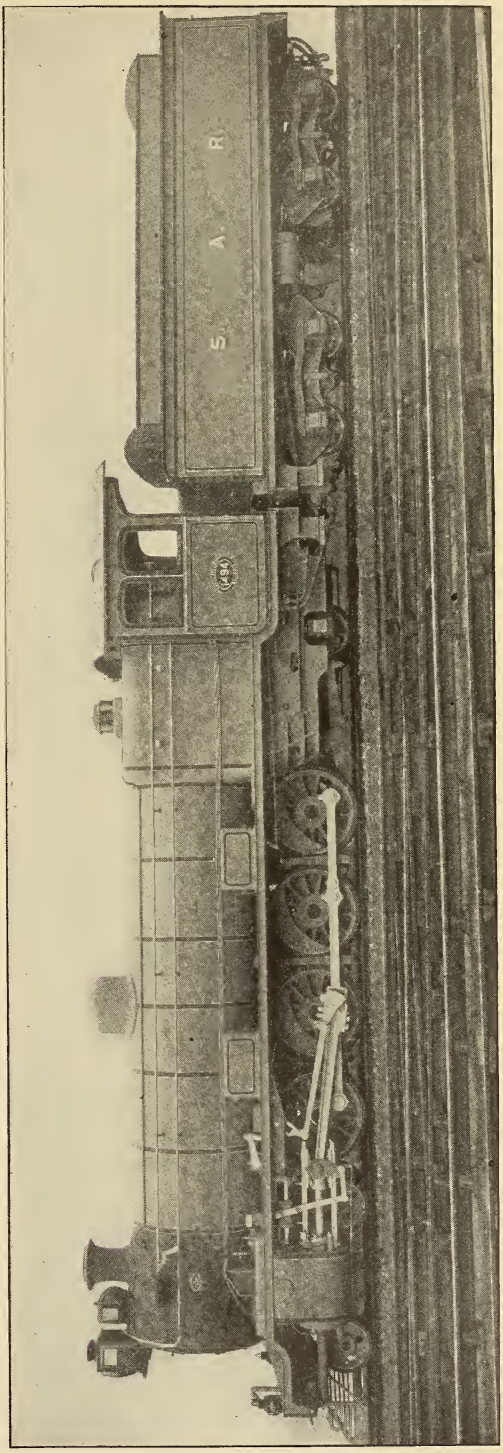


FIG. 17.—LOCOMOTIVE WITH SCHMIDT SUPERHEATER OF THE 4-8-2 TYPE. SOUTH AFRICAN GOVERNMENT RAILWAYS. CONSTRUCTED BY NORTH BRITISH LOCOMOTIVE CO., LTD.

British hands; but similar locomotives are used on two or three other systems in that part of the world. Boiler and firebox, the latter of Belpaire type, are very large and the cylinder dimensions considerable; but as very fast work is not called for, the diameter of coupled wheels is only moderate, reasonable speediness being combined with good load-hauling capacity. A Schmidt superheater is fitted, but the pressure is placed at the high figure of 200 pounds per square inch. The design is particularly neat in many ways, and attention is paid to appearance to the extent of providing a polished brass dome, with bright bands and mouldings round the barrel of the boiler, in addition to neatness of outline.

For some years the locomotive practice of Italy has been exceptionally interesting, and the engine shown in Fig. 15 includes several notable features. Four non-compound cylinders are employed, and the enormous dimensions of the boiler and firebox, in conjunction with Schmidt superheater equipment, render the design a remarkable one, even when compared with the series of unusually interesting 4—6—0, 2—6—2, 2—8—0, 4—8—0 and 0—10—0 locomotives already in service for various main line duties. The cylinders are arranged so that on each side one piston valve controls the steam distribution of two cylinders, as in the four-cylinder compound locomotives of existing classes.

Fig. 16 illustrates a remarkable 4—6—2 engine constructed by The Baldwin Locomotive Works, of Philadelphia, for the Baltimore & Ohio Railroad. Forty of these were supplied during 1911, thirty having Schmidt superheaters, though No. 2140, now represented, is adapted for saturated steam. They are very similar in many respects to 2—8—2 engines already in service. A study of the dimensions will indicate how remarkable these engines are in conjunction with the view reproduced, so that further reference is not necessary, except to state that they represent advanced American practice for very large and powerful locomotives of relatively ordinary types.

In the corresponding article reviewing remarkable locomotives of 1910 published in this magazine for June, 1911, reference was made to the introduction of large 4—8—2 engines on the South African railways, and an engine of a later development constructed by the North British Locomotive Company for the same system is illustrated by Fig. 17. It must be borne in mind that the gauge is only 3 feet 6 inches, and this fact renders the design particularly interesting as indicating possibilities of dimensional development even under such conditions. The design is derived from 4—6—2 and 4—8—0 engines introduced by Mr. Hendrie in recent years in view of the extreme gradient and traffic difficulties experienced on many sections of this great South African system of Government railways; but they are a considerable advance upon the older classes. A Schmidt superheater is fitted, cylinders are large and steam pressure reasonably high, so that, in conjunction with the large boiler power available, the engines are capable of doing wonderful work, even with long inclines of 1 in 33 to surmount, in combination with severe curves in difficult country. They are mainly intended for working heavy goods trains, but occasionally they are used on passenger service on the hardest sections.

During 1911 the same wheel arrangement made its appearance in the United States for heavy passenger traffic under the name of the "Mountain" type, and Fig. 18 illustrates the initial engine of the class, built by the American Locomotive Company for the Chesapeake & Ohio Railway. These locomotives, of which two are at present in service, are claimed to be the most powerful passenger locomotives in the world; and in view of the dimensional possibilities offered by American loading

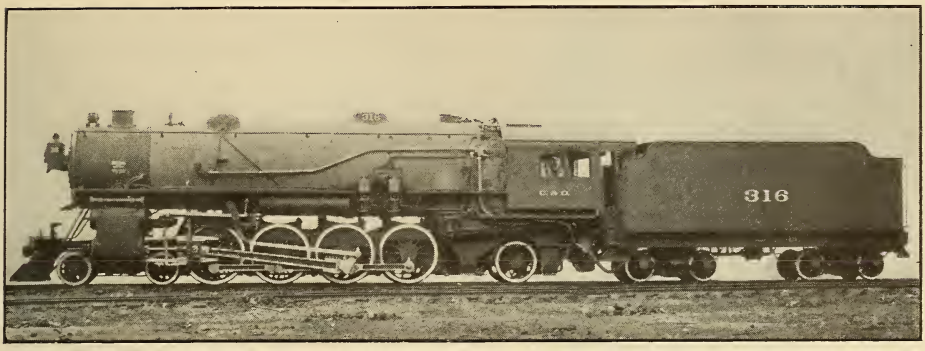


FIG. 18.—MOUNTAIN TYPE PASSENGER LOCOMOTIVE. CHESAPEAKE & OHIO RAILWAY. AMERICAN LOCOMOTIVE CO.

gauges and disregarding articulated locomotives which may be used for passenger traffic, this can hardly be disputed after examination of the dimensions. They have been introduced primarily for working very heavy trains of from 600 to 700 tons over the hardest section of the Clifton Forge division, where grades of 1 in 60 and 1 in 70 have to be ascended, while it is essential that good time shall be made with maximum train weights. Hitherto large "Pacifics" have been used, but as the demands overpowered them it was decided to adopt eight coupled wheels for passenger traffic requiring fairly fast running, and in that connection the "Mountain" type is particularly interesting. In fact, these engines have to average about 25 miles an hour, including stops, so that Mr. J. F. Walsh, superintendent of motive power, and the builders had no easy problem placed before them for solution.

The design includes a very large boiler fitted with a Schmidt superheater of the latest type, while the cylinders have the unusual dimensions of 29 inches diameter, with a stroke of 28 inches. Coupled wheels are 5 feet 2 inches diameter, while a number of special features based on experience, both on the Chesapeake & Ohio Railroad and in the hands of the American Locomotive Company, enabled a remarkable, and, in some respects, unique design, to be produced. The boiler diameter is almost 7 feet, enlarging at the coned ring to 8 feet, while the length of barrel is more than 19 feet.

For some time past the "Mikado" (2—8—2) type has been somewhat extensively adopted in the United States for heavy and relatively fast freight traffic.

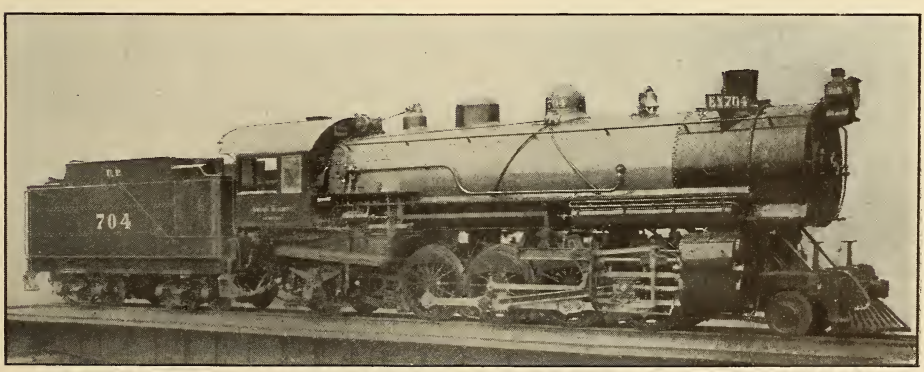


FIG. 19.—MIKADO LOCOMOTIVE FOR THE UNION PACIFIC RAILWAY. THE BALDWIN LOCOMOTIVE WORKS

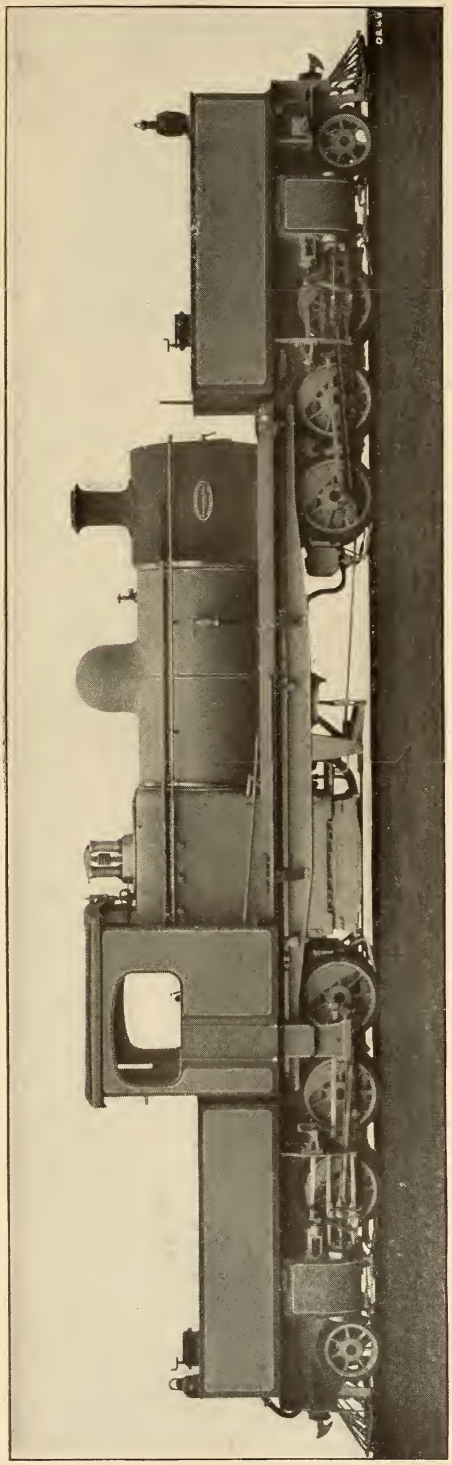


FIG. 20.—GARRATT ARTICULATED LOCOMOTIVE, WEST AUSTRALIAN GOVERNMENT RAILWAYS. BEYER, PEACOCK & CO., LTD.

Locomotives of the class illustrated by Fig. 19 are also intended more particularly for working passenger trains, though, as the demands are not quite so severe, there was no necessity for proceeding beyond the 2—8—2 wheel arrangement. They have been constructed by The Baldwin Locomotive Works for the Union Pacific Railroad, and are intended for operating passenger train loads of about 600 tons between Cheyenne and Laramie at an average speed of 22 miles an hour over a grade of 30 miles, mainly at 1 in 66. Ten engines of this design have been placed in service. Here also the dimensions are very large and noteworthy, but a superheater is not employed, and the design is a development of ordinary methods rather than a collection of novelties and special features.

Among other interesting 2—8—2 designs introduced in 1911 may be mentioned a series of 20 such engines constructed by The Baldwin Locomotive Works for the Great Northern Railroad and 160 built by the same firm for the Baltimore & Ohio Railroad. Twenty of the latter series are fitted with the Schmidt superheater. The American Locomotive Company has supplied to the Chesapeake & Ohio Railroad a remarkable class of 2—8—2 engines. These have many points in common with the "Mountain" locomotives illustrated by Fig. 18, so that the tabulation of dimensions will suffice.

The writer is not aware of any notable ten-coupled locomotives constructed anywhere in 1911, and the only example of the direct connection of six pairs of driving wheels is provided by the Austrian 2—12—0 locomotives described early in this article. But in the field of articulated design a number of extremely interesting locomotives require description, though all of these have their counterparts, in some cases on a smaller scale, in the record of previous years. Perhaps the most interesting of all articulated designs is that known as the "Garratt." The

pioneer engines of this class were constructed for narrow gauge lines, and were of small dimensions, one of them being described in last year's article. But the locomotive illustrated in Fig. 20 is a much larger machine, and includes a number of features of special interest. It was constructed by Messrs. Beyer, Peacock & Co., Ltd., of Manchester, for the West Australian Government Railways. The outstanding characteristic of the "Garratt" design is the fact that the boiler is, as it were, carried bridge fashion upon two engine trucks, so that boiler and firebox dimensions are in no way restricted by the mechanism, and great flexibility on curves is obtained. They were built to the designs of the engineers of the railway, in collaboration with the builders, and were specified to be able to traverse 5-chain curves on a line of 3 feet 6 inches gauge, and to ascend grades of 1 in 22, with the limitation that axle loads must not exceed 9 tons. A noteworthy feature of the design is the fact that very equable weight distribution is obtained, notwithstanding the apparent difficulty of doing so. These are the first "Garratt" engines to be provided with six coupled wheels and a pony truck in each section, and the dimensions are considerably larger than previous engines of the class. The centres of the two bogies are no less than 25 feet apart. Yet the boiler never deviates sufficiently far from the centre line of the track to cause difficulties, even at fairly fast speeds, and the overhang of the parts on the sharpest curves is never serious. In fact, in this respect the design compares favourably with many of the large Mallet articulated engines in service. Piston valves actuated by Walschaert gear are employed, and in the steam dome a duplex type of regulator is fitted. Pipe connections cause no trouble, ball and socket devices being employed for the steam transmission where necessary. A number of special devices are neces-

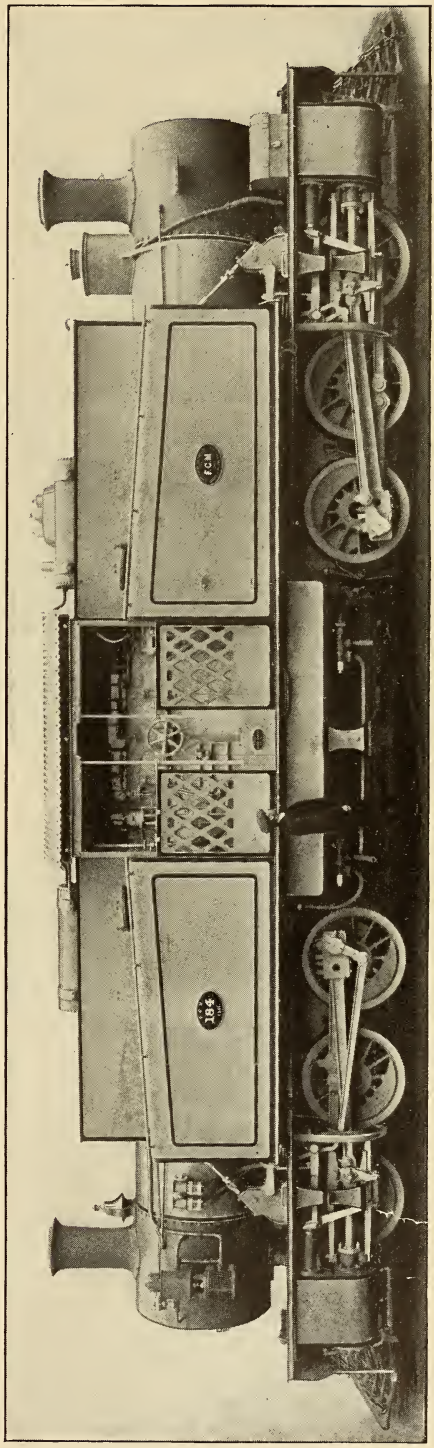


FIG. 21.—FAIRLIE ARTICULATED LOCOMOTIVE. MEXICAN RAILWAY. BUILT BY THE VULCAN FOUNDRY, LTD.

sarily employed, but space will not allow them to be reviewed in detail.

The locomotive illustrated in Fig. 21 is claimed to be the largest "Fairlie" articulated engine yet constructed, and as will be seen from the view reproduced in conjunction with the table of dimensions, the design is an extremely interesting one in all ways. It is used on the standard gauge lines of the Mexican Railway, and was constructed by the Vulcan Foundry Company, of Newton-le-Willows, Lancashire. The recognized characteristics of the "Fairlie" type are retained, there being two sets of coupled wheels arranged in pivoted trucks, while the boiler is in two sections, having a large firebox, fired from one side, common to both. But the dimensions, in view of the severe requirements associated with the mountainous route to be traversed, are notable. In fact, the total weight, all of which is available for adhesion, is 138 tons, and this easily makes it the largest engine ever constructed in Great Britain, especially if the tender weights of very large engines of other classes are not reckoned. Included in the equipment are Richardson balanced valves; reversing gear by wheel, bevel gear, worm and quadrant on flexible shafts and air locking device; Detroit triple-feed, sight-feed lubricators; hand sanding devices; Westinghouse brake mechanism with signal connection for engine and train, and counter-pressure brakes for control when descending long inclines.

Apart from such special classes as the "Garratt" and "Fairlie" types, it is in American practice that the articulated locomotive receives its most remarkable development. Reference to three such locomotives introduced during 1911 will form a fitting conclusion to an interesting review of notable designs associated with that year. It seems almost unnecessary to explain that the peculiar

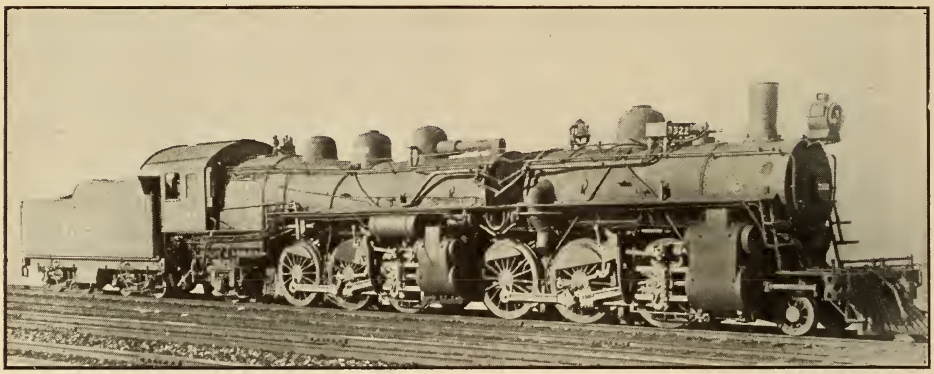


FIG. 22.—ARTICULATED LOCOMOTIVE WITH FLEXIBLE BOILER CONNECTION. BUILT BY THE BALDWIN WORKS

engine illustrated in Fig. 22 belongs to the Atchison, Topeka & Santa Fé Railroad, for that line is recognized as the home of so many extreme developments that there is tendency to attribute all drastic variations in practice to the officers of that road. The engine is one of four constructed by The Baldwin Locomotive Works, having flexible boilers with a bellows joint, and intended for service on what is known as the "Belen cut-off." Twenty corresponding engines have rigid boilers. Both classes are rated for 2,400-ton train loads on grades of 1 in 140. Most of the characteristics now associated with extreme developments of the Mallet type are included, the front extension in advance of the bellows joint containing a feed-water heater and a Jacobs superheater and reheater. The firebox is stayed on the Jacobs-Shupert system, and contains

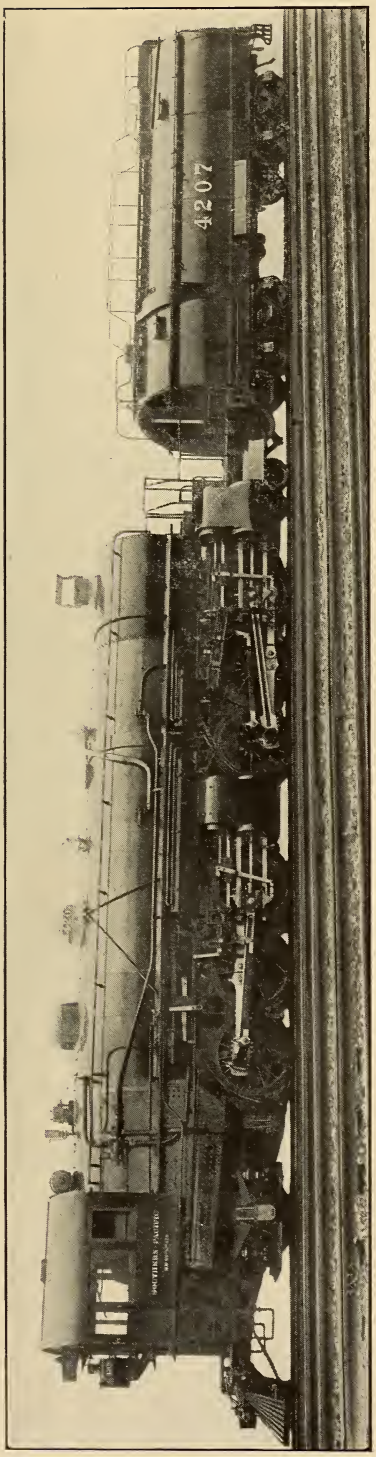


FIG. 23.—ARTICULATED LOCOMOTIVE FOR PASSENGER SERVICE. SOUTHERN PACIFIC RAILWAY. THE BALDWIN LOCOMOTIVE WORKS

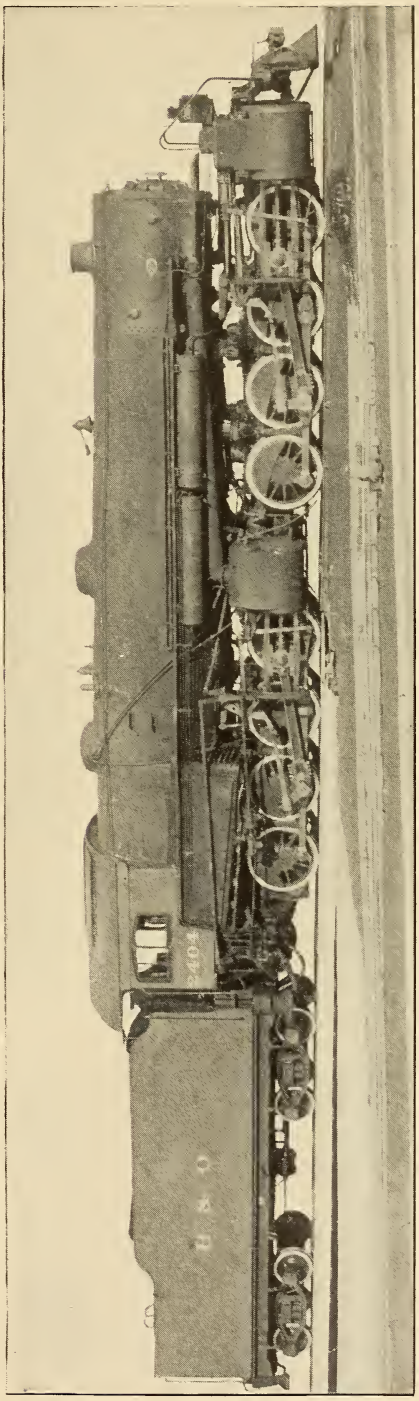


FIG. 24.—ARTICULATED LOCOMOTIVE OF THE 0-8-8-0 TYPE. BALTIMORE & OHIO RAILROAD. AMERICAN LOCOMOTIVE COMPANY

DATA OF LOCOMOTIVES ILLUSTRATED AND DESCRIBED.

T = Tank Engine. C_4 = Four-Cylinder Compound. CM = Mallet Compound.
B = 3′ 6″ Gauge. D = 3′ Gauge. E = 5′ 6″ Gauge. F = Metre Gauge.

Fig.	Railway.	Builder.	Type.
1	North Eastern (England).....	North British Loco. Co., Ltd...	4–4–2 S_3
	North Eastern (England).....	North British Loco. Co., Ltd...	4–4–2 S_3
2	Great Central (England).....	Railway Works.....	2–8–0
3	Northern (France).....	Railway Works.....	4–6–4 C_4
4	Austrian State.....	Floridsdorf Co.....	2–10–0 C_4
5	A. T. & S. F. R.R. (U. S. A.) ...	Baldwin Works.....	2–10–10–2 C_4
6	Chekiang (China).....	Berlin Engineering Works.....	4–4–0
	North Stafford (England).....	Railway Works.....	4–4–2 T
	Great Western (England).....	Railway Works.....	2–6–0
7	Antioguia (Colombia).....	Borsig Works.....	2–6–0 D
8	Great Eastern (England).....	Railway Works.....	4–6–0
9	L. & S. W. Ry. (England).....	Railway Works.....	4–6–0 S_4
10	Northern (Spain).....	Hannover Engineering Works..	4–6–0 C_4
11	Argentine Northern.....	Borsig Works.....	4–6–0 F
12	L. N. W. Ry. (England).....	Railway Works.....	4–6–2 T
13	Great Central (England).....	Railway Works.....	4–6–2 T
14	Sao Paulo (Brazil).....	North British Loco. Co., Ltd..	4–6–2 G
15	Italian State Ry.....	Ernesto Breda.....	4–6–2 S_4
16	B. & O. R.R. (U. S. A.).....	Baldwin Works.....	4–6–2
17	South African Government.....	North British Loco. Co., Ltd..	4–8–2 B
18	C. & O. R.R. (U. S. A.).....	American Locomotive Co.....	4–8–2
19	Union Pacific (U. S. A.).....	Baldwin Works.....	2–8–2
	C. & O. R.R. (U. S. A.).....	American Locomotive Co.....	2–8–2
20	West Australian Ry.....	Beyer, Peacock & Co.....	2–6–6–2 A B
21	Mexican Ry.....	Vulcan Foundry Co.....	0–6–6–0 A T
22	A. T. & S. F. R.R. (U. S. A.) ...	Baldwin Works.....	2–6–6–2 A C M
23	Southern Pacific (U. S. A.).....	Baldwin Works.....	2–6–6–2 A C M
24	B. & O. R.R. (U. S. A.).....	American Locomotive Co.....	0–8–8–0 A C M

DATA OF LOCOMOTIVES ILLUSTRATED AND DESCRIBED.

S_3 = Three-Cylinder Simple. S_4 = Four-Cylinder Simple. A = Articulated; G = 5′ 3″ Gauge.

Superheater.	Cylinders, Inches.	Coupled Wheels, Ft.	Ins.	Steam Pressure, Pounds Square Inch.	Heating Surface, Total Square Feet. a	Grate Area, Square Feet.	Weight, Tons, Engine Only.	Fig.
Schmidt.....	16½ x 26 (3)	6	10	160	2,509	27.	77	1
Schmidt.....	15½ x 26	6	10	180	2,340	27.	76¾	
Robinson.....	21 x 26	4	8	170	2,009	26.	72	2
Schmidt.....	17⅝ x 25⅝ / 24⅝ x 29⅜	6	8	227	4,158	46.	99	3
Schmidt.....	17¾ x 26¾ / 29⅞ x 26¾	4	9	235	3,186	53.8	94¼	4
Jacobs.....	28 x 32 / 38 x 32	4	9	225	8,897	81.9	275	5
.....	18⅛ x 23⅝	5	9	170	1,260	24.7	45¼	6
Schmidt.....	20 x 26	6	0	160	1,281	21.	68	
Swindon.....	18½ x 30	5	8	200	1,566	20.5	62	
Schmidt.....	14²/₅ x 20	3	6	170	1,120	24.	27	7
Schmidt.....	20 x 28	6	6	180	1,919	26.5	64	8
.....	15 x 26 (4)	6	7	200	1,920	31.5	76	9
Schmidt.....	15⅜ x 25⅝ / 23⅜ x 25⅝	5	10	170	.....	....	69	10
.....	17⅜ x 24⅜	5	3	170	1,404	23.5	44½	11
Schmidt.....	20 x 26	5	8½	175	1,333	23.9	77	12
Schmidt.....	20 x 26	5	7	165	1,649	21.	86	13
Schmidt.....	21½ x 26	5	6	200	2,029	28.5	80½	14
Schmidt.....	18 x 27¼ (4)	6	8	170	2,990	37.8	86	15
.....	24 x 32	6	2	205	5,017	70.	117	16
Schmidt.....	22½ x 26	4	3	180	3,139	40.	91¾	17
Schmidt.....	29 x 28	5	2	180	5,076	66.7	147	18
.....	26 x 28	5	3	200	5,527	70.	123	19
Schmidt.....	29 x 28	4	8	170	5,124	66.7	140	
.....	12½ x 20 (4)	3	3	175	1,340	22.6	66½	20
.....	19 x 25 (4)	4	0	185	2,984	47.7	138	21
Jacobs.....	24 x 28 / 38 x 28	5	9	220	5,176	63.	170½	22
.....	25 x 28 / 38 x 28	5	3	200	7,117	70.	172	23
Schmidt.....	26 x 32 / 41 x 32	4	8	210	6,529	99.9	209	24

feed-water tubes and firebrick tubes.

The engine illustrated in Fig. 23 is an adaptation of the Mallet type for passenger service, and is one of twelve locomotives constructed by The Baldwin Locomotive Works for the Southern Pacific Railway, working on the Sacramento division of the Central Pacific section. Maximum grades of 1 in 45 have to be surmounted, and there is a total rise of 7,000 feet in 105 miles. The boiler has a separate front section containing a feed-water heater, but is not equipped with a superheater or reheater. There are feed-water tubes in the firebox. Oil fuel is burnt, and this permits of the fuel and water supplies being carried in a tender attached at the chimney end of the engine, the driver's cab being placed in the leading position so as to obtain an effective and complete look-ahead. In view of their employment for passenger traffic these engines have coupled wheels somewhat larger than is usually associated with freight working.

Finally, a notable articulated engine of the 0—8—8—0 type is represented in Fig. 24, constructed by the American Locomotive Company for the Baltimore & Ohio Railroad. They are used on the Cumberland-Grafton division, mainly for pushing service on grades of 1 in 35 and 1 in 40, where also very sharp curves are involved, and are intended to deal with 1,750-ton loads, with a "Consolidation" engine at the head, the latter being rated at 475 tons on these grades, so that the bulk of the work is left for the "pusher." A Schmidt superheater is employed, together with the usual features of equipment associated with such designs and with several detail improvements.

The writer is indebted to the various firms and railways mentioned for photographs and particulars of the locomotives illustrated or described, and acknowledgment of their courtesy is hereby rendered. It would be possible to include many other interesting designs, but the selection reviewed is thought to present the principal features of locomotive development during 1911 in the principal countries of the world.

SCIENTIFIC MANAGEMENT AND SCIENCE

By P. Ballard

THERE is something rather pretentious and objectionable in the term "Scientific Management" that invites criticism.

The continued repetition of high-sounding titles is suggestive of the advertisements of proprietary medicines; the substitution of them for real worth has been raised to an art by showmen of all descriptions. The insistence on the word "Scientific" suggests to the skeptical that an analysis of the system to which it is applied will reveal disappointing facts; neither does he have to make a very exhaustive research into the controversy that has grown up round the phases before finding the symptoms expected.

Here is a concise statement of the meaning of scientific management: "It contains two basic ideas. One is the planning of industrial activity from the consideration of its simplest units; the other is the predetermination of standards of efficiency."*

It will be clear to anyone that the foreman who prices his piece rates will judge the time to be allotted to the job in question by summing up the elementary processes of turning, boring, etc., which are necessary for its completion. It is also quite clear that he must have some idea, born of experience, of the minimum of labour necessary for these processes, or, in other words, of the standard of efficiency. The two basic ideas, therefore, of scientific management contain nothing new whatsoever. The process of collecting and tabulating data to guide our judgment in these matters is important, but is an inevitable development from the piecework foreman mentioned above, and cannot claim to be considered as management at all.

If we were making a more exhaustive study of the controversy on the subject we should find that almost all the discussion showed a surprising lack of definition and clearness. Thus, we are told that it "cannot be too clearly emphasized that scientific management is a body of principles and not a system."†

It is a little hard on the engineer who, looking for information on the subject to help him in organizing his shops, finds himself thus carried into the realms of metaphysics when he might well be expecting to find the most practical scheme of management. This indefiniteness, however, goes further than we have yet indicated, and we find that the confusion as to the system, or lack of system, to be adopted springs from a similar indefiniteness as to desired results. Thus, an increase in profits is triumphantly tabulated as a proof of the improvements given to the trade by the science, on the one hand, while on the other, and perhaps in the same article, the writer claims his victory on the grounds that increased efficiency in production has been attained. Either or both of these may be "consummations devoutly to be wished"; but surely it is very important to distinguish between them, since it is an obvious truism that before discussing a science for the accomplishment of any given purpose we must have a purpose given.

It may be argued that since neither an increase in profit nor an increase in efficiency can be obtained without the other, it therefore matters not which our scientists have in view.

* A. Hamilton Church, "The Meaning of Scientific Management," *Engineering Magazine*, April, 1911.

† The same article as that already quoted.

If the premises were correct, no doubt the deduction would follow logically from it; but it will not need a very searching inquiry into industrial and business practice to find methods by which profits may be made to rise and fall without affecting the efficiency of production. An elementary knowledge of economic history—or, failing that, a little imagination—will furnish schemes of production in which profit is neither attained nor considered to be desirable. (The word profit is here used, of course, in its economic sense.)

It is now quite clear that we cannot apply, without discrimination, the tests either of increased profits or of increased efficiency, so that it will be necessary before drawing up a scheme of management to determine for which it is we are striving. Neither is it difficult to arrive at this decision, since being engineers and not financiers, it will be safe to say, without argument, that considerations of efficiency must have precedence over those of profit.

The controversy up to the present time has shown such a lack of definition in either purpose or methods that "Scientific Management" so far appears to mean neither a system nor a set of principles, and at best must be considered as a term applied to the general attempt on the part of the engineers to set their houses in order by establishing a due relationship between the various departments, commercial and mechanical. This is effected, on the one hand, by getting more work done with the given mechanical and man power, and, on the other, by relatively, if not actually, cutting down the wages bill and establishment costs and thus leaving a larger margin of profit.

Such is obviously the modern tendency; various managers adopt various systems to attain the same end, the underlying principles remaining the same; but to dignify these principles with the title of "Scientific Management" is (to borrow an expression from Ben Jonson) "more than most ridiculous." Such a title could only be applied to the results of an elaborate generalization of those different tendencies which have shown themselves in the very varied departments of production which come within the limits of the engineering trade.

Even this generalization to claim the high title of scientific must understand its limits far more clearly and rid itself of the many totally unscientific pretensions made by the present "Scientific Management." At the same time, it must widen its basis, classifying the modern tendencies as progressive or reactionary by a very much more general standard than that which is set up by the profit and loss account of the firm which may happen to adopt them; for even now that we have distinguished between efficiency and profit-making, and have given the latter the preference, yet it is still certain that we shall have to conduct our inquiry on quite other principles before making any serious attempts to formulate our science.

One of the first misgivings that shakes our faith in the test of efficiency presents itself to us in the question: Does the consideration of efficiency allow sufficiently for progress—are the chief essentials of activity of all kinds? Doubtless the instruments and methods of production will improve and advance, even though there may be no other incentive behind that progress than the desire for the elimination of waste labour; but this does not result in any development in *that which is produced;* and thus, if efficiency of production merely is to be considered, it appears that the elements of progress have been represented in details only.

To attain a predetermined standard of efficiency may be good, but it is better to see that that standard itself is always moving higher. This moving force is nowhere generated, fostered, or even allowed for in the

principles of scientific management.

It must not be forgotten here that the whole engineering industry may be looked upon as an instrument of production, and that in this the widest efficiency becomes the sole motive force behind its progress. In dealing with the question of management applied to individual shops, however, it is impossible to keep this fact always in view, and thus the arguments already used against the efficiency test must hold good.

We are now driven to abandon the atempt to found our science on the evidence of account books or time sheets and wages alone, and have to search for some more general data and facts upon which to work.

Scientists and philosophers, in their researches into the developments of all the phenomena of Nature, have been able to generalize from their studies certain laws of development or conditions of progress. The existence and growth of the engineering industry are subject to these laws, just as is all in Nature, and our first duty should be to study them and be certain that whatever plans may be adopted, either as general principles of management or as schemes to meet the emergencies of special conditions that may arise, they shall accord with these general laws.

Herbert Spencer, who gave to the world his synthetic philosophy, expounded his system in his famous "First Principles." To attain and to demonstrate the laws of evolution or progress he covered a wonderfully wide range, showing how the developments of our social system, of a language, of science, of art, take place in accordance with these laws no less than does the evolution of any organism or of a solar system. We are, therefore, doing nothing fantastic in applying these general principles to the development of the engineering industry.

What, then, are these laws, so universal in their application? It would be impossible to state them fully here, together with their application to our subject, and it will, perhaps, be sufficient if we quote the first two. They may be expressed in two words, "Integration" and "Differentiation." Here are two quotations from the first two chapters on "The Law of Evolution," a section of the "First Principles," to which reference has been made before: (1) Evolution is "the process which is always an integration of matter and dissipation of motion, but which . . . . is, in most cases, much more than this." (2) "To say that along with the primary redistribution there goes secondary distribution, is to say that along with the change from a diffused to a concentrated state there goes a change from a homogeneous state to a heterogeneous state. The components of the mass, while becoming more integrated, have also become differentiated."

Now considering the engineering trade, we find it has developed both in detail and in general tendencies along those lines which might be expected from a study of the first law quoted above—namely, that of "integration."

The old machine tool was ungainly and "sprawly" in construction, while the modern tool boasts of its small floor space and compactness of design; the modern automatic turret lathes perform the process for which various machine tools were responsible but a few years ago, and perhaps furnish the most striking examples of integration in the trade; the beam engine of the days of the pioneers of steam engineering has been "integrated" into the little steam turbine, or internal-combustion engine of today. So we might take innumerable examples of the manifestation of this law by considering the machine alone; but, by taking a little wider view, we see its influence in a manner bearing even more directly on our subject.

Among those firms occupied in the same branch of a trade there continually appears an increasing ten-

dency to group together. The shipbuilding yards on the banks of the Clyde or Tyne might be taken as an instance of this; or, again, the centralization of the cycle and motor trade at Coventry, or the cutlery industry at Sheffield, might serve as examples. Taking a yet wider view, we may instance the "integration" of the trade in general at such towns as Glasgow and Manchester and the tendency of the works in various other districts to make their way towards those great centres. (The direct causes of these changes are of no significance to the present discussion.)

It is not surprising to find that, in harmony with these tendencies in modern machinery and in the distribution of industry, there is also a tendency (not universal, of course) among the promoters of the trade to substitute co-operation for competition; and thus we see the growth of the large combine, in which capital unites or integrates to organize industry. It is not difficult to see that the next step is the centralization of management, and that because of this huge centralization the discussion of "Scientific Management" springs into prominence.

Thus we understand the origin of our subject, but it is at this point that our second law of evolution, "differentiation," or increasing heterogeneity, becomes also important. Let us examine it in its relationship to the trade.

The automatic lathe has been quoted as an instance of "integration"; it now remains to be pointed out that before this integration can take place there must have been differentiation. It is not necessary to prove that screw-cutting, although developed early, was unknown in primitive mechanics, while roughing and finishing have become more and more distinctly two separate processes, and "cutting off," again, is now the duty of a specially designed machine tool. All these processes have been "integrated" into the automatic lathe, but the integration is meaningless unless considered in relation to the differentiation.

The first motive forces of mechanics were taken *directly* from the powers of Nature, and the movements of the waters and the winds were utilized; but in more modern times latent forces of Nature are also liberated, and through the steam engine we utilized a potential force, while still later we have evolved the various forms of the internal combustion engine.

The purely mechanical side of the industry would furnish an endless supply of such examples of differentiation, but we will pass on, as we did in examining the application of our first law, and consider it in a wider aspect.

The older shops undertook engineering in a more or less vague sense until the trade became more important and its application wider (as machinery gradually tended to supersede manual labour). Later, we find the trade split up, the various shops for different purposes becoming more and more unlike each other. Thus, we have to-day shops for crane-making, bridge-making or shipbuilding, machine-tool making, or the making of machinery for special purposes, such as printing, chocolate manufacture or lace making—in fact, a vast variety of shops for different purposes, or, in other words, a most striking example of differentiation.

Within each works also the same process has gone on and the division of labour has produced either by the side of, or instead of, the "all-round" man, a pattern maker, moulder, turner, fitter and erector, each occupied in its own department; while, again, even within these departments a similar distinct differentiation of duties has been going on.

Finally, it must be noticed that the existence of the great "combine" means that the life of the organization depends upon the proper fulfil-

ment of many very varied functions, and, further, upon *the ever-increasing variety of these functions.*

It is this law of increasing variety or differentiation that managers, scientific and unscientific, are prone to forget; indeed, judging from the usual attitude of the management, we might be led to suppose that its chief mission were to resist this form of progress.

In order to make our study as complete as possible, it is, perhaps, well to mention here a tendency towards uniformity, which, apparrently, at any rate, conflicts with the almost universal tendency to multiformity hereby illustrated. "Interchangeability of parts" and "repetition work" are phrases with which every engineer is familiar, while the modern works, much more than the older shops, even to the casual observer, give the idea of repetition, from their "saw tooth" construction to the rows of similar machines performing like operations inside.

How far this tendency could be accounted for by the "Rhythm of Motion" (again to quote Herbert Spencer) it would be very difficult to say, and we must be contented in this article with simply making the suggestion; certainly the tendency must be admitted, for no one would suggest that a railway wagon should have four wheels varying in design,* yet neither can it be denied that a great amount of repetition work today is injurious, opposed to progress, and is prompted by a narrow-minded policy. Many a design has been spoiled by the "economy" of repetition. At any rate, certain it is that standardization and repetition work cannot possibly be a source of progress, and that, on the contrary, progress can only come by breaking down the old standards and establishing new; and in this sense standardization must always, without exception or condition, be opposed to progress.

In our study now of the relationship of management to the first laws of progress, as might have been expected, we are reaching very different conclusions by applying the tests of wide and general laws from those obtained when the test of dividends is alone considered, for dividends are but indirectly related to the subject of engineering, and, at the most, should be taken merely as an indication of increasing efficiency when other things remain equal. Remembering that all progress is, among other things, a transformation from the simple to the complex, or from the uniform to the multiform, we are forced to see that increasing management itself is (like larger doses of medicine) an indication of a diseased organ.

Further, when that management begins to talk of more standardization and uniformity, as managements are wont to do, then we wonder where in this scheme the first essentials of progress have been admitted.

A fairly wide range of inquiry has already been covered, in order to get as universal and as well balanced a view of the problem as possible; there is yet one other point with which it would be profitable to deal, for it will clearly indicate how one-sided are the judgments so often pronounced in our technical papers, owing to the narrow outlook which is taken. Allowing one's imagination to wander for a moment over towns which owe their fame to the engineering industry, we are able to see that the question of scientific management, if it is not first of all and essentially a sociological problem, at least must be considered under this aspect before anything like a complete study can be made of it. Remembering this, let us inquire for a moment what is the usual attitude of our technical papers towards that social "management" known as the government. Practically uni-

* Yet even here it is interesting to notice that our more complex vehicles (motors or locomotives) have wheels of varying sizes and strength (driving wheels and bogy wheels, etc.), while railway wagons are being constructed every day in increasing numbers of special designs.

versally they oppose any interference on the part of the government, maintaining that those responsible for the various industries in society are more likely to be able to deal with the special conditions, needs and difficulties of the industry than is any central power, which cannot be expected to have the necessary specialized knowledge. Thus, to take a recent example, the first leader in *The Engineer* for August 11, 1911, begins:

"It has been estimated by a French political economist that every social law diminishes the profits upon industry by 3 per cent., and that with thirty such laws it would be impossible to carry on business at all. Although this number has not yet been reached, the effects of the social reforms already put into operation are sufficiently onerous to bear out, at least in part, the truth of this maxim. So long as industry is prosperous it can support such burdens without apparent inconvenience, but as soon as a slack time gets in the social mill-stones are sufficiently heavy to drag it down."

Although, perhaps, the process of reasoning may be very different, yet the conclusion reached and stated in the paragraph above is very similar to the truths deduced by Buckle from his studies of historic facts:

"It would be easy to push the inquiry still further and to show how legislators, in every attempt they have made to protect some particular interests and uphold some particular principles, have not only failed, but have brought about results diametrically opposite to those which they proposed. We have seen that their laws in favour of industry have injured industry; that their laws in favour of religion have increased hypocrisy, and their laws to secure truth have encouraged perjury."

Or, again:

"But it is absurd, it would be mockery of all sound reasoning . . . . to expect any benefit from future legislators, except that sort of benefit which consists in undoing the work of their predecessors.

It is doubtless impossible for the politicians directly concerned in this legislation to see it from the point of view of those quoted above, unless they adopt a wider method of inquiry than is usual with politicians. Remembering, then, their errors, it would be well if those people who place their faith so implicitly in scientific management would ask themselves whether there may be a possibility that their "management" will suffer from the same defects and will have a similar influence over the various departments of their particular industry that this much, and rightly, abused government exercises over the social industry as a whole. Just as the various bills and acts of Parliament have been discussed in different trade papers and their fallacies pointed out, so in the same way, doubtless, the acts of our managements, scientific and otherwise, could be criticised from the points of view of the various departments, and the narrow-minded policy of encroachment might thus be shown to be attended by like evils to those which accompany the increasing interference of government.

We have already hinted at the conclusions to which this inquiry must inevitably lead us. The scientific management of the future will have to cater for and encourage progress. Instead of attempting merely to standardize, make more uniform and regulate more fully from its centre out to the parts, it will have to allow these parts the free initiative to break down standards and forsake the beaten path of its repetition work, it will have to become and to recognize itself as the *result* and not the *cause* of orderly production; for production itself is an orderly process.

In fact, this phrase "Scientific Management" may perchance still be unsuited to describe the future system of industry; but this will be because of the inapplicability of the second and not the first term to the then existing form of organization.

HYDRAULIC POWER

I.—ITS GENERAL UTILITIES

By Joseph Horner

SOME of the spheres in which pressure water has held its own for many years have been invaded by electricity, variously generated, and by compressed air. In these it has suffered in company with steam. Each of these agencies occupies some sphere to which, by common consent, it is better suited than any of the others. But the fields in which hydraulic power still retains an unassailable position are yet very numerous and of wide extent. It holds in its possession two vast monopolies, one of which includes the moving of heavy masses in nearly all conceivable constructions, the other some machines, and machine tools of many kinds. We propose to consider these and to offer some criticisms and suggestions bearing on those applications where hydraulic methods are met by the rivalry of other power systems.

Wherever a mass of many tons weight has to be moved with great precision at irregular intervals that is a prima facie case for the employment of pressure water. It is so simple to pump water to any pressure and store it in an accumulator ready for use that no better agency can be desired. Or, without the storage of the accumulator, enormous pressure can be produced by direct pumping and utilized by rams which can be applied in a hundred different mechanisms and industries. It is just a problem primarily of the proportioning of the pump plunger and the ram plunger, and secondarily of length of stroke, of water-saving devices, and of suitable mechanical details, such as quality or disposition of metal, of packings, joints and arrangements. The elements are simple and the details are not intricate.

The enormous energy which is stored in water-power at the ordinary pressure of 750 to 1,500 pounds, and the extraordinary—up to, say, 4 tons per square inch—and its inelastic character, are the features which render it of so much value as a medium for the transmission of great powers. In these respects it is unapproachable either by steam or compressed air. The slow and precise character of its direct movement is a point in its favour in the moving of heavy masses and in exercising pressures for which steam or electricity would require reduction gear. On the other hand, its rate of movement in cylinder or accumulator can be multiplied when desirable until, as in ordinary crane work, speeds of 150 feet per minute are regularly employed, and in the jigger these may be doubled.

And the simplicity of the hydraulic system would often ensure its installation and retention apart from its other advantages. The pressure can be regulated exactly and the quantity of power be tapped precisely. The loaded accumulator is an admirable device for regulating the pressure by the weights hung on it or put into the weight case. When the supply required is intermittent the engine keeps the accumulator full. Its throttle valve is in connection with the accumulator, which closes the throttle valve when the accumulator is at the top of its stroke. When a supply is being drawn the sinking of the ram opens the throttle valve and the engine resumes pump-

ing. In this way, though the abstraction of water is intermittent, the pressure is continuous and unchanged. No elastic fluid can operate thus. When the water is not being drawn on, the accumulator holds a supply, and the pumping engines stop working. Neither is there any important loss of power in transmission in hydraulic mains.

We may consider two aspects of hydraulic power. One is that in which, in the light of our present knowledge, it does not appear likely or possible that any other power agent can take its place; the other, that in which electricity may with greater or less probability be substituted with advantage, for the rivalry now only lies between these two agents.

First, let us endeavour to postulate the conditions which are or are not unquestionably fulfilled by hydraulic power alone. All boiled down, it seems that there is only one, the exercise of high pressures in a small space of time—nothing more. Previous to the applications of electric power the hydraulic agent possessed the advantage of transmission over long distances. But electricity shows to much better advantage here. An experiment made in the mains of the London Hydraulic Power Company demonstrated the fact of transmission of power over five miles. Two accumulators situated at that distance apart, one loaded higher than the other, were put into connection directly, and the heavier one raised the lighter one through the medium of the water in the intervening five miles of pipe. But electricity may be transmitted a hundred or two hundred miles.

Although one may justifiably hold the faith that hydraulic power has an unassailable position in certain spheres, particularly those of heavy duty, it must be admitted that there is a borderland in respect of which such a belief must now be in some cases tinged with wavering doubts. One would not have thought until very recently that the big coal tips ever would or could be actuated by any power but pressure water. Yet electricity has begun to elbow that out. And the same thing is happening in dock equipment. With the exception of two previous electrically-operated coal hoists on the Continent, no hoists of this kind had been fitted electrically until four years ago, when the Clyde Navigation trustees erected two 32-ton coal hoists at the Rothesay Dock. Great interest was aroused by this fact, and especially as some other machines formerly hydraulically-driven were powered by electricity, including, besides ordinary cranes, twenty-nine capstans and two tipping turntables. This installation, in which electricity has been employed to the exclusion of hydraulic, has given satisfaction, and it is as economical and reliable as hydraulic, while the electric lighting being an additional duty, improves the load factor. There are, however, no big dock gates to be moved nor sluices to be opened, the docks being tidal ones; and these, we believe, are duties typical of many others where hydraulic operation is the most advantageous.

Mr. Walter Pitt banteringly observed in connection with this installation that "he noticed that their hydraulic friends left out the crowning glory of the hydraulic crane—namely, the great ease, as he knew from experience, with which it could be converted into an electric crane. On the cylinders being taken out, an admirable space was obtained for the collector for the leads, and on the back of the crane there was a place, just as if it was made for it, onto which the electric motors could be bolted." Things, of course, are not come to that pass yet; but the rivalry of the newer agency must be admitted by hydraulic engineers and met, if met at all, by cheaper power-water. For that, in the case of cranes and capstans, is the usual basis of comparison. But an immense sphere of occupation is still left

TRIPLE-POWER, 25-TON HYDRAULIC CRANE. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

which, as far as appears at present, electricity cannot invade.

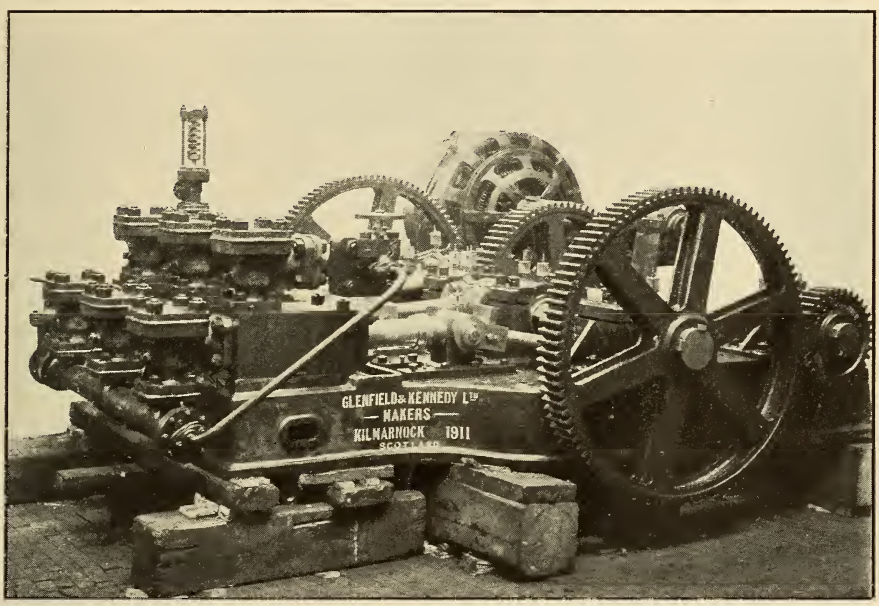
When the hydraulic and the electrical engineers each advocate the superiority of their respective system, which they represent by comparative figures, it is soon seen that a common basis which is even only generally acceptable does not exist; for not only is the question of relative cost involved in such a comparison, but the nature of the service also, and particularly the regularity or irregularity of the loads must count, since as much water is used, apart from water-saving devices, in dealing with a light as with a heavy load. Also, as in many machine-tool operations,

one operation cannot be considered alone, but it must be regarded in its relation to a complete cycle of operations.

There are great differences in the cost of pressure water, which may range from 2*d*. to 1*s*. 9*d*. per thousand gallons. This, therefore, in any comparison with electricity must be taken against the cost of current. Col. Tannett Walker throws blame for the high cost of pressure water on the inferiority of some hydraulic plants. "Why should not the mechanical engineer have the same highly expansive, beautifully made triple engines to drive hydraulic machinery as the electrical man has to drive his dynamos?" Then he thought there was no difficulty in producing power at 2*d*. or 3*d*. a thousand gallons. The cost of electric power depends largely on the method of its generation, as does that of gas. And just as illuminating gas has been superseded by producer gas made from inferior fuel and by waste gases from blast furnaces, so, too, the generation of electricity is cheapened in favoured localities by the employment of waste water-power, or, where that is not available, by the centralization of generating plants, notably as on the North East Coast of England, largely using inferior fuel and waste gases, and again in many cases by burning municipal refuse. Central distributing stations are now supplying electricity to private firms over large areas at much lower costs than these can generate current for themselves. Current, wherever and how-

MOVABLE 25-TON HYDRAULIC COALING CRANE. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

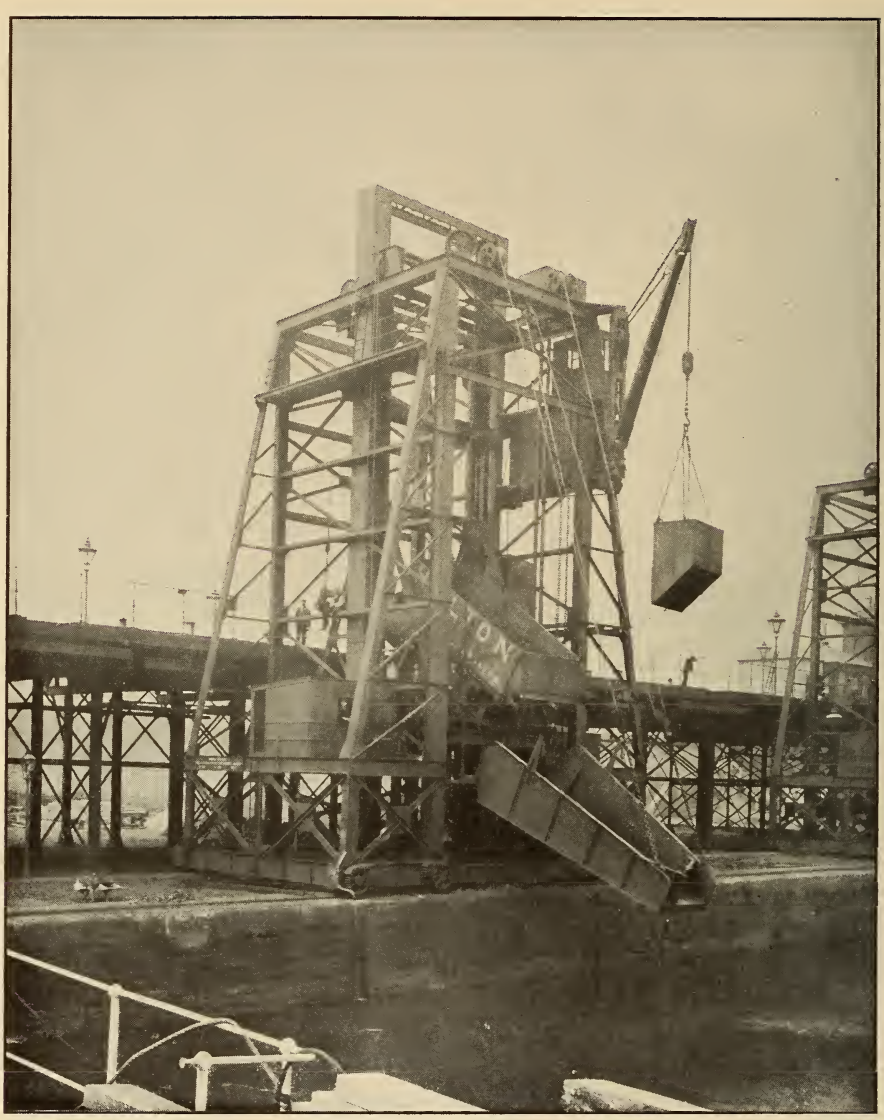
ever generated, can be transmitted anywhere, and used for lighting as well as for power. And practically all types of modern machine tools as now built, the undoubted hydraulic tools excepted, are constructed so that with slight modifications they can be driven either by belt or by an electric motor direct. These facts explain why hydraulic power in many of its applications has been hard hit. Electricity at 1½*d.* per unit (kilowatt-hour) is the mechanical equivalent in foot-pounds, or Watt hours, of pressure water at 9.8*d.* per 1,000 gallons at 750 pounds pressure per square inch.



HYDRAULIC THREE-THROW RAM PUMP. GLENFIELD & KENNEDY, LTD., KILMARNOCK

5½ inches in diameter x 12-inch stroke, with 40 revolutions per minute. To deliver 100 gallons per minute at 1,500 pounds per square inch. Test pressure, 3 tons per square inch

But before a satisfactory comparison can be made between electrical and hydraulic power some considerable time must elapse. The advent of a new agency, as of a new machine, stimulates improvement and invention. Many familiar illustrations could be cited in steam power plants, in the planing machines, the turret lathes, the cranes, the worm gears, etc. The rivalry of electrical machines reacts on hydraulic, in improved workmanship in one direction, in more economical working in another, so bringing the rival sets of conditions more nearly on an equality. And when all the possible rivalry is admitted, there remains still an immense field, which, as far as one's prescience can pierce, hydraulic power must always occupy without a probable rival. Even though it be admitted that the spheres hitherto monopolized by hydraulic machinery will probably become more circumscribed in future as central station practice extends, the last word is not said. Electric power is now sold so cheaply that hydraulic schemes will be hard put to compete with it. Yet there remains the fact that hydraulic machinery is less liable to get out of order than electrical, and it requires less skilled attendance. The smoothness of movement and the high efficiency at full loads are in its favour. It compares unfavourably with electricity when another plant has to be laid down for lighting and

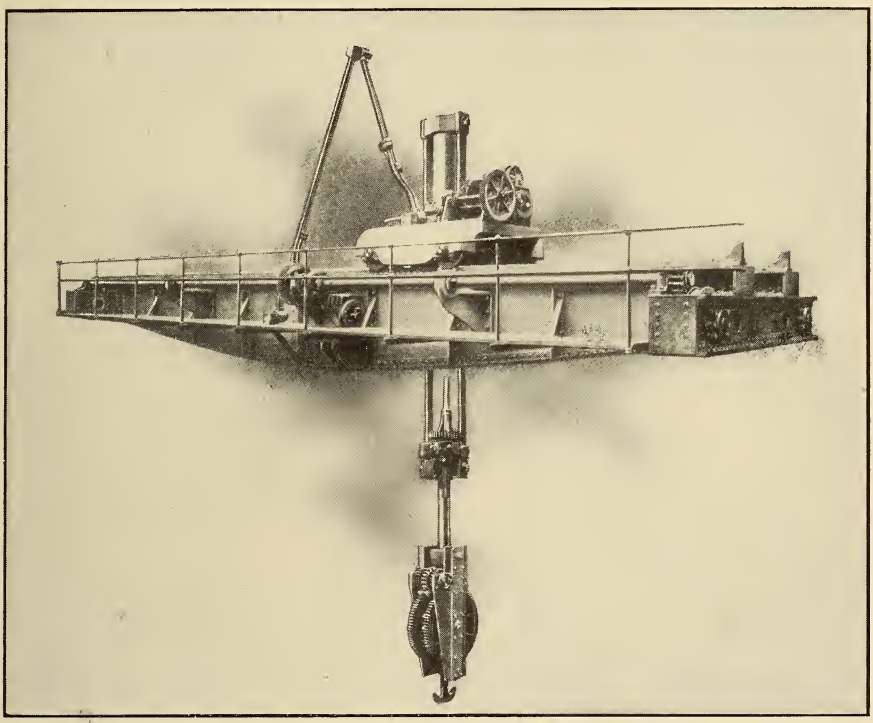


DIRECT-ACTING, 30-TON, MOVABLE HYDRAULIC COAL HOIST. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

for driving electrically-operated machinery. There must always be risks of frost, and generally some leakage and sloppiness. But moisture, which is injurious to electrical machinery, is not hurtful to hydraulic. Troubles, due to short circuiting and to the burning of fuses, do not worry the hydraulic engineer. His principal renewals are leathers and packings, and his principal care is to have clean water, free from grit, which would score the rams and glands. This, however, is generally used over and over again, and thus can be kept free from foreign matter. An objection to hydraulic machinery is, that for a given stroke or lift of ram the same quantity of water is used for minimum as for the maximum loads, while in electrical machinery the power used corresponds with the

work done. But only in some classes of work would this difference put the hydraulic machine out of count because of its extravagance. In others water saving is largely practiced. And it has stood a much longer test of utility and reliability than electric power has. A fact which must count as in favour of hydraulic machinery is this of its re-

spheres—that to the operation of cranes. But at present relatively few small cranes are built for hydraulic operation, except in association with an existing hydraulic plant, because electricity has appropriated those of small and even medium dimensions. But heavy cranes are still commonly constructed to employ water, especially in places where an hydraulic



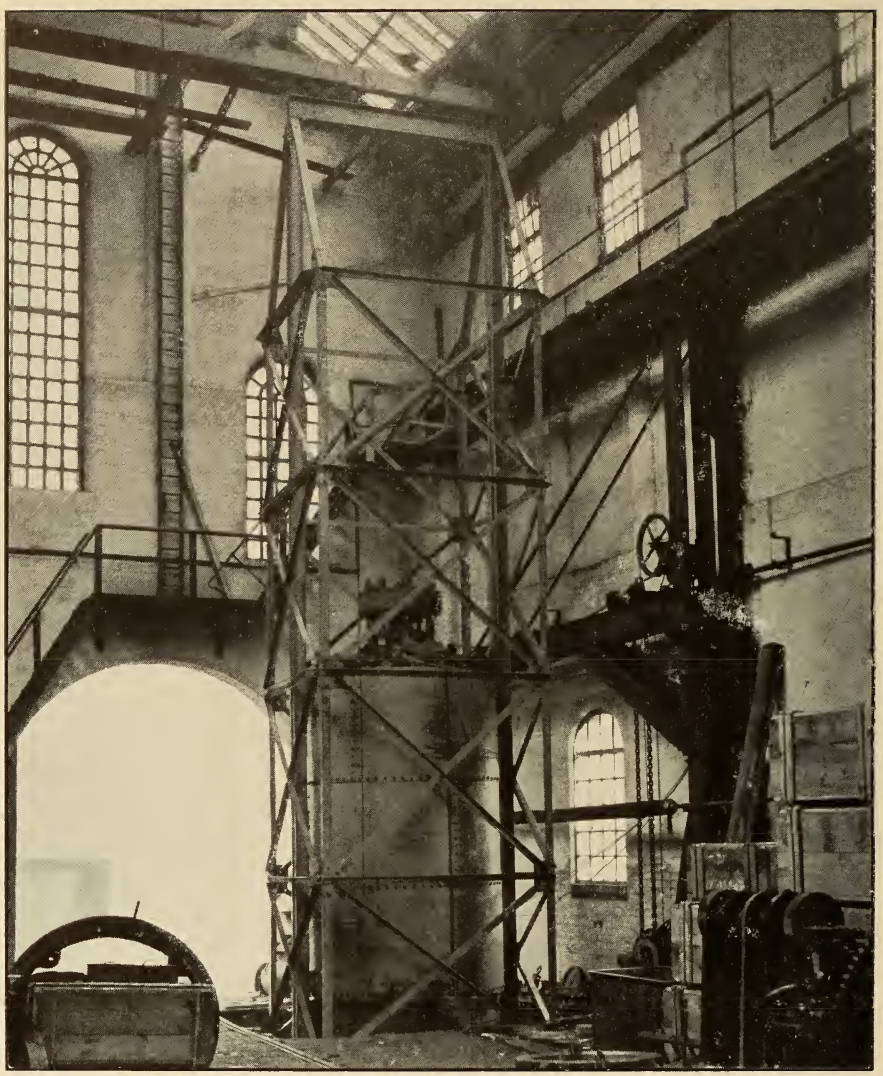
COMBINED HYDRAULIC AND ELECTRIC FORGING CRANE OF 60 TONS, WITH A SPAN OF 50 FEET.
HENRY BERRY & CO., LTD., LEEDS

The traveling, traversing and turning gear are electrically driven; the hoisting is hydraulic

liability. With the occasional renewal of a leather and by the exercise of ordinary care the hydraulic plant is a very safe standby. Some plants have been in service for more than a generation and still remain efficient. Massiveness, smooth and slow movement, a small number of parts—all conduce to reliability and permanence.

Some interest centres in the fact that the earliest application of water-power is also still one of its largest

plant is already installed. That indeed is often the determining factor. Another which counts is whether cranes are fixed or portable. The first is very favourable to the hydraulic agent, the second to the electric method of operation. On large numbers of wharves and docks now systems of electric cranes are installed which would a few years ago have been built for hydraulic driving. The field still occupied by heavy cranes appears to be that of the



HYDRAULIC ACCUMULATOR RAM, 12 INCHES IN DIAMETER, STROKE 15 FEET, WITH ELECTRICAL OPERATING GEAR. GLENFIELD & KENNEDY, LTD., KILMARNOCK

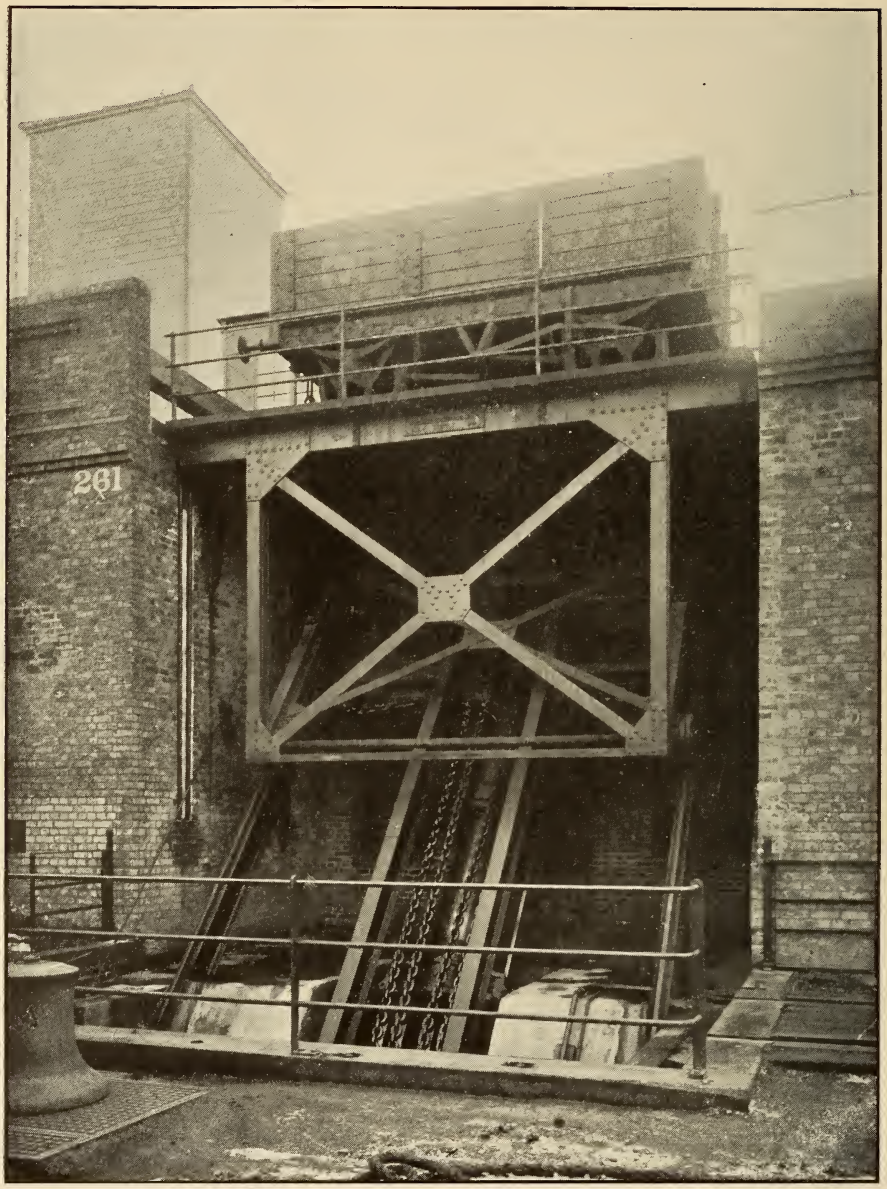
heavy coaling hoists and tips, such as are seen at the South Wales ports, and in many English ports also. Hydraulic power seems more suitable for coal hoists and cranes than electric, because the coal dust which permeates everywhere would cause less injury to the machinery of the first than of the second.

With regard to the waste of water in dealing with light loads, this is greatly lessened by increasing the number of rams, paralleled by the two, three or more motors commonly used on electrical cranes. In most of the Penarth coal tips three rams are used; in some cases two only; and there are besides balancing arrangements—and all to save water. Thus the general objection that the same amount of water is used in lifting light as heavy loads is got over, and the cranes are on the same economical footing as electrically-driven

ones, in which the power used is proportioned to the work done. The familiarity of the jigger is the only reason why it is not more highly appreciated, the case of users excepted, for there are thousands of jiggers in service, but by the men who advocate electric cranes. Just a ram moving in its cylinder, and operating chains passing over multiplying sheaves to do any work that comes along. The ram in moving outward moves also the sheaves farther apart, and so causes a pull on the load, whatever that happens to be. The principle is modified for both fixed and portable service. The jiggers will handle light loads, four or five a minute. Speeds up to 400 feet a minute can be obtained. Suspended lifts are also worked by them, and warehouse cranes, the crane being then simply a guide for the rope or chain operated by the jigger.

The largest spheres in which hydraulic power retains its own with little or no rivalry lie in numerous industrial developments which had not come to birth when water-power began to invade the provinces hitherto held by steam, or in many cases by hand power. Some of the most notable applications of water-power now are seen in the big steel works, not so much in the cranes as in the forging and ingot presses. Nothing can take the place of water for these presses. Many problems arise and are met in connection with this group of machines—problems of water saving and of the strength of elements chiefly. In the manipulation of heavy steel work, plates and sections, the hydraulic tools are unrivaled, and must continue to be so. In the old days of the "iron age," when plates and sections were all light, steam-driven machines were most common, driven by belt or by independent engines. Relatively few of these survive, but the machines are now hydraulically operated. And many machines that were non-existent then have been devised to perform functions that were either not done at all in iron or were performed in other ways. The most imposing among these are the machines which bend heavy plates and sections, and flange, punch and rivet, spheres in which steam and compressed air are of little value. The employment of mild steel has given us immensely bigger vessels, and, therefore, vastly larger docks and dock equipments are necessary, and hitherto hydraulic power is the principal agent for opening and closing the immense gates and the sluices. Swing bridges are wider than formerly, and these are turned hydraulically. Several ports on the Continent have been equipped wholly with electricity. But it must be remembered that the new agent has not had the long test of experience which the older has.

Since high hydraulic pressures cost money in the form of coal and steam to pump, economies have to be practiced when very high pressures and large quantities of water are being used. Hence the employment of more than one pressing ram is frequent, so that a selection can be made suitable to the load or the pressure required. More common is the employment of separate rams for pressing and lifting. The latter are only put under just sufficient pressure to lift the mass of a crosshead and main ram or of a table, according to the character of the machine, while the main central ram does the actual pressing. These occur in very many variations, not only in hydraulic forging presses, but also in many moulding machines, etc. After an ingot has been squeezed the ram is lifted by two subsidiary rams working under very low pressure, being only just sufficient to counterbalance the weight of the main ram. During the lowering of the pressing ram, instead of using the high-pressure water to fill the cylinder throughout its descent another supply of water is used at a low pressure, usually about 750 pounds, being only sufficient to counteract the pull of the subsidiary cylinders. Then when the ram is low



INCLINED WAGON HOIST OPERATED BY HYDRAULIC JIGGER. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

enough to begin its actual squeeze, the full pressure is put on it.

It is matter of common knowledge that steam hammers for very heavy work have practically disappeared before the hydraulic presses. The dismantling of a newly built steam hammer at the Bethlehem Works a few years ago in favour of a 14,000-ton press, which was an object lesson in scrapping, is typical of much that has happened since. The concussion, noise and sparks produced by the hammer are all absent from the press and the penetration is better.

The intensifier or differential accumulator figures largely in powerful hydraulic work. It may be actuated by steam or by water. By its use a low pressure can be converted into a high one, the difference being in the ratio of diameter of the two pistons, so that there is no limit except the strength of the material to the mechanical advantage available. In fact, the principle is adopted in many of the highest powered forging presses. Usually the rams are in the same axis, but this is not essential. A long stroke at low pressure can be converted into a short one of high pressure by making the high-pressure ram hollow for the ram of the low-pressure cylinder to pass into.

The Hydraulic Engineering Company, Ltd., of Chester, have a differential accumulator with one ram of uniform diameter, but in which pressures range from 400 to 1,500 pounds per square inch by the superposition of another weight for each additional hundred pounds of load. The vertical angle sections which receive the cross bracings of the frame have holes to receive wrought iron bars on which such weights are held when not in use. The ram is fixed at top and bottom and the cylinder has a stroke of 6 feet on it.

In the Davy forging presses steam is used in conjunction with water for working the intensifier, and also for lifting the crosshead with resulting rapid action. The standard steam pressure used is 150 pounds and the hydraulic 2½ tons per square inch. The steam cylinder is below, and the hydraulic cylinder above. The plunger of the latter is of nickel steel. The valve is coupled to an automatic controlling gear, which is an inclined bar actuated by the piston rod through the entire length of the stroke. It closes the steam valve and opens the exhaust automatically, so that the intensifier cannot overrun. The pressing cylinder uses the water from the intensifier for pressing only, the presser head being lifted by two steam cylinders, one on each side of the entablature, with lifting rods attached to the presser head. An air vessel is included with its charging and air pumps. These presses are made in two designs, with pressures ranging from 150 to 1,500 tons.

The intensifier in principle is applied directly to the working of pumps for the use of tunnel shields. A low-pressure water cylinder becomes the motor to actuate high-pressure pumps in tandem at opposite ends. A pressure of 750 pounds per square inch in the motor cylinder is intensified to 2,240 pounds per square inch in the pumps. The motor cylinder is 7 inches diameter, fitted with a gunmetal piston, the rods of which, 3 inches diameter, are prolonged and in one piece with the piston, to form the plungers of the high-pressure pumps.

An electric installation can readily be worked economically in conjunction with an hydraulic one. It is done in the case of heavy lifts for railway stations. Although the hydraulic plant is usually distinct from the electric, in several recent instances the latter has been operated from the former. To install steam or gas engines would often be objectionable, but if the pumps are driven electrically that objection is got over. Such an installation has been put in by the Hydraulic Engineering Company, Ltd., at Finsbury Park station of the Great Northern & City Tube Railway and at other places. The action, too, is automatic, like that of accumulator pumps, only that rheostats and switches automatically cut off the current and stop the motors when the hydraulic accumulator reaches the limit of its upward movement. They are similarly started when the accumulator descends.

In another article we propose to pass in rapid review the principal applications of hydraulic power.

MECHANICAL APPLIANCES ON THE PANAMA CANAL

IV.—DREDGING AND CONCRETE CONSTRUCTION

By J. F. Springer

THE principal subaqueous excavation on the Panama Canal is in connection with the two sea-level sections. The width of the channel throughout both portions is 500 feet. The minimum depth of water is to be 40 feet.

It will be seen from these facts that we have here a very considerable dredging proposition. This was early recognized by the canal authorities. Up to June 30, 1911, there had been removed from the canal prism by dredging operations in these two sections a total of 52,559,100 cubic yards of material. The average cost was about 24 cents per cubic yard, including administrative and general expenses. The French left behind them several ladder or elevator dredges, which have been put to some use. However, the great work in these two divisions has been done by two sea-going suction dredges—the *Caribbean* (formerly the *Ancon*) and the *Culebra,* which are sister-ships. Both were built by the Maryland Steel Company, Sparrows Point, Maryland (on the east shore of the Chesapeake, a little south from Baltimore). The length of the *Caribbean* is 488 feet, with a molded beam of 47½ feet and a molded depth of 25 feet. Propulsion is effected by a pair of twin screws. Her pumping machinery consists of two 20-inch centrifugal pumps. This vessel made the trip from Sparrows Point under her own steam in about nine days. Without equipment, she cost $362,425. Arriving at the Atlantic terminus of the canal in August, 1907, she at once began operations upon the prism of the waterway. A mile and one-quarter was taken as a suitable working length. The width of the channel, it will be remembered, was required to be 500 feet. She would begin operations at the southern end of this stretch and work seawards, steaming slowly along, with her two pumps going and her drags sucking up mud. By the time she would cover the mile and one-quarter she would have received into her bins all that would readily settle. Raising her suction pipes, she would then steam out into the Caribbean Sea, off Toro Point, which lies on the western side of the entrance to Limon Bay, and dump her spoil. Working twenty-four hours per day, this great dredge would make about one complete round trip in one and one-half hours, disposing of about 750 cubic yards of mud per trip, or about 12,000 cubic yards per day. However, on Saturdays, when coaling was done, she would be compelled to omit the larger part of the dredging which otherwise would have been accomplished on that day.

The sister-ship, the *Culebra,* sailed from Sparrows Point in October, 1907, and made the trip round the southern extremity of South America to her destination at La Boca, on the Pacific side of the Isthmus, under her own steam, in eighty days. Considerable heavy weather was encountered en route. For eighteen hours she was in a hurricane. About nineteen days were spent at the various ports, so that her average speed while actually at sea was about 9 knots per hour for the entire trip of 12,000 miles.

The tide fluctuation in Limon Bay is so small that no part of the work of the *Caribbean* is ever disclosed—

unless, perhaps, close up to the shore. On the Pacific side, however, as the "Record" tells us, the channel dredged by the *Culebra* is visible from the shore at low tide. It is said that this dredge can excavate at a depth of 60 feet. It seems that occasionally she has dredged the prism to 50 feet below mean sea level, although 40 is all that is required. The work of a great sea-going dredge cannot be handled with minute precision. The effect of the sea itself would prevent this. The furrows made by the dredging shoes are each 5 feet wide. When going over the route again the vessel cannot be run with such exactitude that the new furrows will precisely join with the old. However ,the movement of the sea and the interference of furrows together result in a smoothing out of irregularities. There is nothing whose specific gravity is too great to resist the suction of such dredges as the *Caribbean* and the *Culebra*. The holes in the dredging shoes are 6 by 9 inches. The size of these openings is the only limitation upon the material on the sea bottom. The *Culebra* has pumped up a chain having a length of about 60 feet. The *Caribbean* picked up a cannon ball. It will be seen at once that pieces of rock present no difficulty, when it is observed that the specific gravity of iron in water is about 6½ and of rock about 2. The crew on the *Culebra* (in 1908) were working in four-hour watches. Each man was on duty two watches in the course of twenty-four hours. Meals were served four times in the same period—at 6 A. M., 12 noon, 6 P. M. and 12 midnight. Sixty men constituted the force employed. Officers and men received the same food. It is said that a temperature of 130 deg. Fahr. was at one time quite usual. But this excessive heat seems to have been eliminated by an improvement in the ventilating arrangements. It was, in fact, difficult to keep the stokers, many leaving the same day they began work. The *Culebra* would dredge over a length of two

INGERSOLL-RAND ROCK DRILLS AT PANAMA, NEAR EMPIRE

miles in forty minutes. The bins are 20 feet in depth and have a capacity of 1,200 cubic yards each. However, the pumps did not deliver solid material alone. In fact, it was customary to estimate 40 per cent. of the delivery of the pumps as water. Consequently, such a dredge as the *Culebra* will really excavate about 1,400 cubic yards of solid material per trip. With ten trips per day of twenty-four hours, the daily total would amount to 14,000. In October, 1908—which had four Sundays—the *Culebra* excavated a total of 431,537 cubic yards, or an average of nearly 16,000 cubic yards per day. During her first ten months of service this dredge excavated 3,862,794 cubic yards of material. The dredges discharge their spoil by opening the bottoms of the bins. This operation is performed by power-driven mechanism.

These two dredges are doing the great bulk of the subaqueous work. But they are unfitted to deal with unbroken rock. There have been two general methods of dealing with this used on the canal. One of these methods operates by blasting and then removal by suitable dredges. The other method proceeds by smashing the rock with a very heavy chisel, when dredges may remove the débris. The Lobnitz rock breaker is the apparatus by means of which the latter procedure is carried out. The barge containing the mechanical appliances is securely moored in the desired location. There is a vertical hole or well at the centre of this barge and extending clear through it. Through this well the great ram, resembling a chisel, is operated. This ram weighs 15 tons or more, and secures its results by falling vertically through the water onto the ledge of rock to be broken up. The ram is raised to its initial position by means of a powerful winch. It is then dropped by simply releasing a clutch. Ordinarily the distance of the fall is not more than 4 or 6 feet. If the mechanism is running smoothly, a complete cycle of movements may be gone through in fifteen seconds. Without moving the barge, a circular area of 2½ feet radius may be broken to the depth of 3 feet. To get the penetration of 3 feet requires anywhere from fifteen to eighty blows. Of course, the character of the rock makes a great difference. Seven men take care of the entire apparatus. The rock breaker on the Panama Canal, which began operations on the Pacific end, is called the Vulcan. She began work on August 21, 1909. On October 2 the ram was lost, on account of slipping off the edge of the ledge of rock. It went down into the muddy bottom to a depth of 60 feet, and was not recovered until after five days of effort. The Vulcan employs three lengths of ram, to meet the fluctuating condition of depth of channel and height of tide. These are 30, 40 and 56 feet, and the corresponding weights are 15, 16 and 19.5 tons.

The body of the ram is of compressed steel; the cutting portion is of hardened steel. It is necessary to lift and drop this heavy weight repeatedly. An A-frame, 65 feet high, supports a sheave, through which passes the 2-inch steel cable by means of which the lifting operation is performed. A winding drum suited for continuous running operates the cable. There are "automatic gear and a lubricated steel friction clutch." The arrangement is such that when the ram falls the cable follows the movement. Accordingly, it is possible to begin the return movement immediately after the ram has made its impact. The Vulcan is 100 feet long and 28 broad. She has an electric light plant, and provides quarters for her crew. In moving over the area she operates upon locations 4 feet apart. Unless she is working over bare rock it is ordinarily necessary to perform a preliminary dredging operation. As before noted, the Vulcan began work on August 21, 1909. Compared with the record for the remaining ten months of the fiscal

INGERSOLL DRILLS WORKING AT LOS CASCADAS, CANAL ZONE

year, the performance during August would seem to have been a preliminary trial. A total of 140 holes were made in August, requiring altogether 3,763 blows. The penetration per blow was only 0.12 inch. The total average penetration per hole was 3.19 feet, which compares very well with subsequent work. In the following month 1,603 holes were made, having a total penetration of 4,235 feet. The average penetration per blow was 0.36 inch—three times as much as before. The average penetration per blow for the remainder of the fiscal year ranged from 0.29 foot in October to 0.76 foot the following month. For the whole period—August 21 to June 30—the total number of holes was 15,961, in making which 106,256 blows were struck, an average of 6.66 blows per hole. The total penetration amounted to 49,786 feet, or 0.47 foot per blow. The average penetration per hole was 3.12 feet.

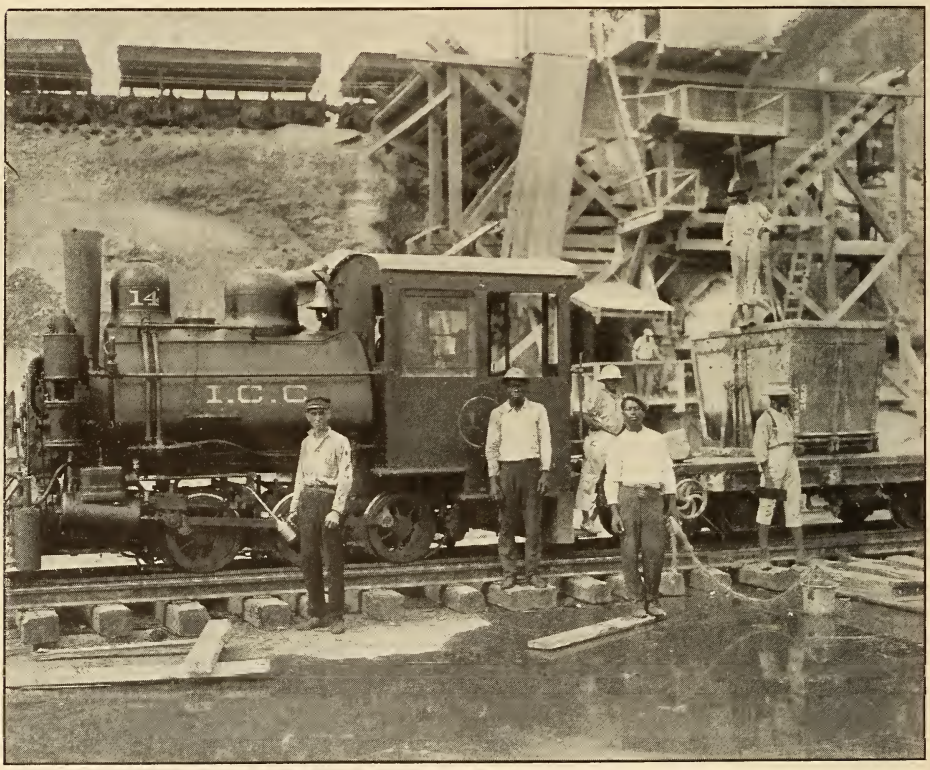
The method which proceeds by blasting may be carried on in two ways or more. Thus, at the Pacific entrance a wet and a dry blasting procedure have been employed. For wet blasting, a barge carrying a number of drills was used. A 20-foot hole may be put down in one hour. Such a hole was bored in that time in the spring of 1910 in water that was 40 feet deep at high water. Probably, more such holes were put down in just as good time, but of this one we have a record. The rock was hard trap. After the holes are bored to what seems a suitable depth, they are charged with dynamite, which is then exploded.

A drill barge, appropriately named *Teredo,* began work in March, 1910, and had drilled in the course of four months a total of 7,508 linear feet. The total number of working hours was 1,040, so that the average distance drilled per hour was 7.22 feet. The number of holes blasted—which probably differs but little, if any, from the number of holes put down—was 407. The average amount of dynamite per hole was 17.8 pounds. The average amount of dynamite per linear foot of hole was 0.96

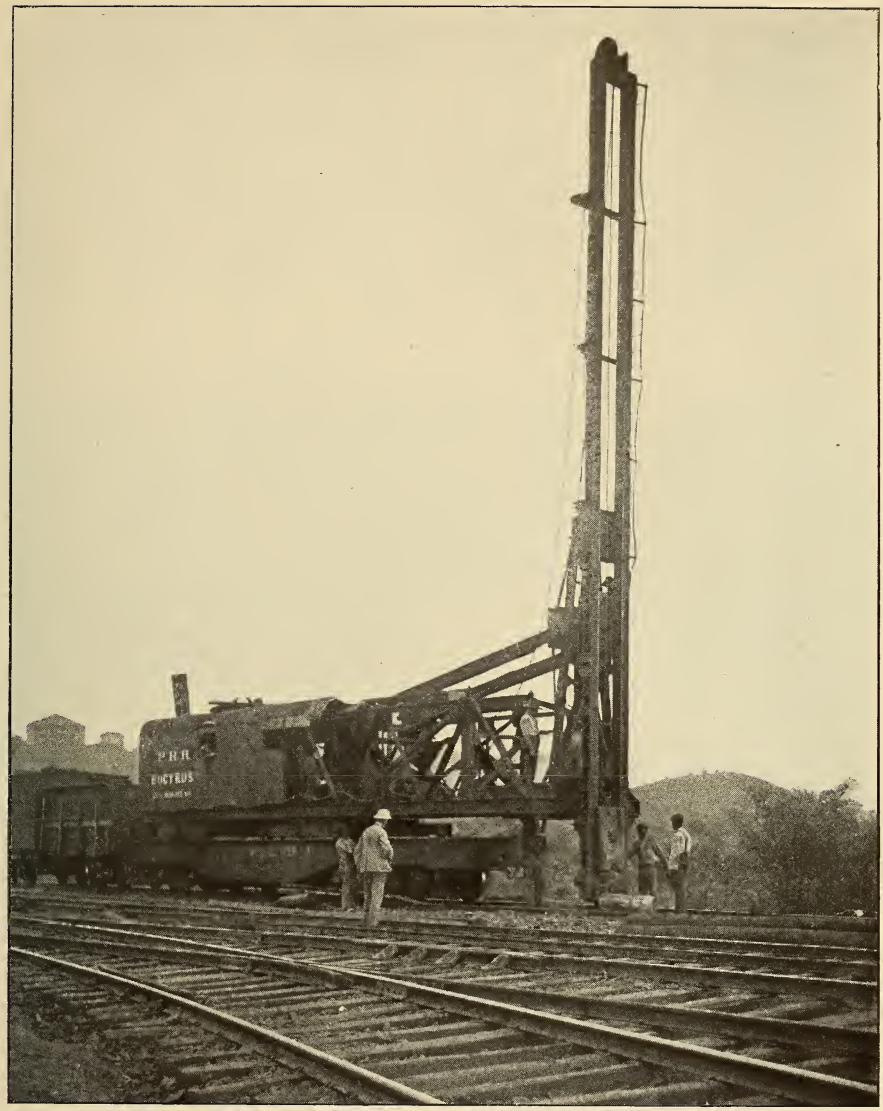
pound. The *Teredo* is a steel barge, 112 feet long and 36 feet 8 inches broad. She is divided by vertical bulkheads into twenty-one watertight compartments, of which two are used for water tanks. A number of other compartments are employed, to contain six tanks of oil, each holding forty barrels. To maintain the barge in position timber spuds are located at the four corners of the barge. Each spud is sectionally 24 inches square, and is operated by means of a rack and pinion. An independent engine is provided for each spud. To maneuver the barge, kedge anchors and manila ropes are employed.

Along one gunwale three drill frames, 38 feet in height, are movably arranged on rails laid lengthwise of the barge. The movement is effected through an endless chain, which, in turn, is driven by hydraulic means. Each frame carries a slide capable of vertical movement. On each slide is secured a 5½-inch rock drill. The operation of the slide by a hydraulic ram provides a means of raising and lowering the drill through a range of 10 feet. The vertical adjust thus permitted is necessitated by the fluctuations of the tide, which are often very considerable on the Pacific side. Drill rods of unusual length are employed to accommodate the great changes of water level. The horizontal range of the drills is 85 feet with the barge in any given fixed position. The holes were being located, in effect, at the centres of rectangles 6 feet long and 5 feet wide, so that a single hole dealt with an area of 30 square feet.

Dry blasting can sometimes be used; it depends upon the situation. Excavation required near the Pacific



SMALL ENGINE USED FOR CONVEYING WORK ON THE PANAMA CANAL



BUCYRUS PILE DRIVER AT WORK ON THE PANAMA CANAL

end between Corozal and Balboa included land that was dry part of the time and submerged part of the time. Here churn drills were employed in boring holes 4 inches in diameter. These were carried down to 50 feet below mean tide. It is said that about 21 feet of the depth was through hard rock. A considerable number of such holes would be bored 15 feet apart. A small amount of dynamite would then be exploded in the bottom of each to enlarge it at this point. Twenty holes thus enlarged would be charged with about 400 pounds of dynamite each. The whole 4 tons of the explosive would then be set off simultaneously by means of electricity. The wiring of the holes would be in series. Dipper and ladder dredges would clear away the broken rock resulting from the ex-

plosions. The same method was employed at the Atlantic end of the canal, though probably no enlargement of the holes was found necessary.

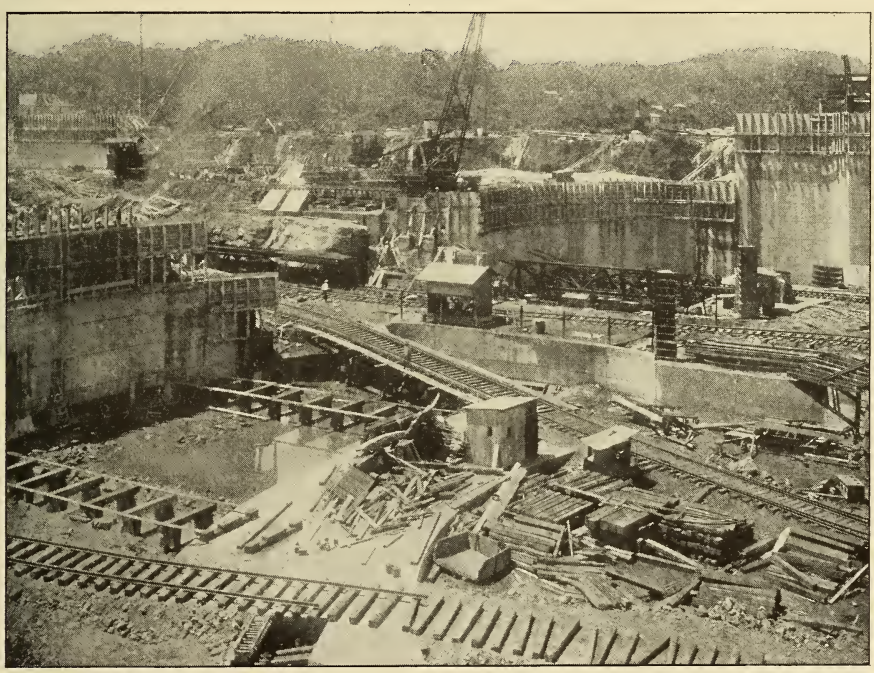
It will be instructive to glance a moment at some of the results. During the fiscal year ending June 30, 1910, an average of twelve drills per month were employed, each of which drilled an average of 603 linear feet per month. This is an average of about 23 linear feet per working day. No doubt, a considerable amount of time was necessarily expended in other ways than in actual drilling. This daily average is to be regarded as the amount actually drilled, in spite of all delays and auxiliary operations. The total drilled by all twelve drills amounted to 86,827 linear feet. The total of dynamite exploded was 345,865 pounds, or an average of 4 pounds per linear foot. If we count only the 35,938 linear feet of rock drilling, then 9.6 pounds of dynamite were used per linear foot. The amount of broken rock has been estimated at 274,339 cubic yards, so that we have the average of 1.26 pounds per cubic yard.

That the dredging operations are of great importance when looked at merely from the point of view of volume, may be seen from a few statistical statements. When the Americans took control on May 4, 1904, they had ahead of them a total of dredging excavation confined to the terminal sections amounting to 69,379,610 cubic yards. This is comparable to what was ahead in dry excavation. More than half—35,864,211 cubic yards—belonged to the Pacific end of the canal. To the Atlantic end belonged the remainder—33,515,399 cubic yards. By the time this article appears the dredging will probably have been completed—that is, it will probably have been completed once. Dredging will, no doubt, be an unending job on the canal. Tidal and other movements of the sea will tend to wash in mud and close up the terminal channels. This may be expected to be an important consideration on the Pacific end, where the tidal movements are large.

HYDRAULIC EXCAVATION

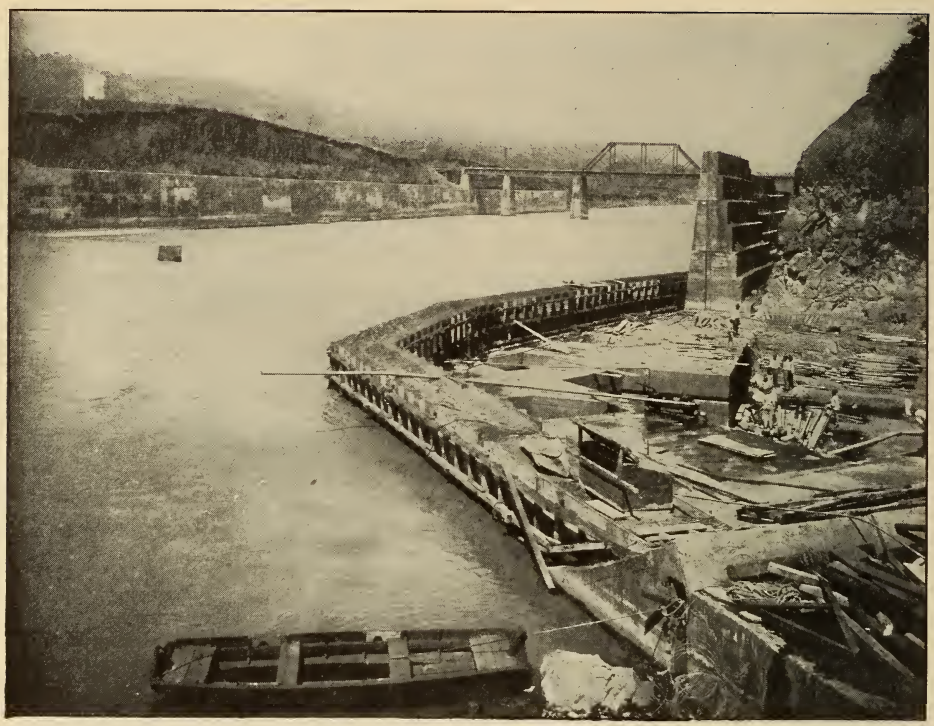
The sea-level section between Miraflores Locks and Panama Bay is in a low-lying district, in large part below the level of high tide. The character of the material on the northern part of this section, together with other considerations, has led to the decision to carry on a great part of the necessary excavation by the hydraulic method. The site of the pair of lower locks is included in this portion. South of that for a distance of perhaps a mile and a half the site of the canal itself constitutes the remainder. Altogether, it was estimated, there was a total of about 8,000,000 cubic yards of material which might be excavated by this method. Two things, we are told, are involved in the practical application. The material to be excavated must first be broken up and sluiced into sumps. Apparatus operating from barges on the surface of the sumps must then lift and remove the material—now in a disintegrated condition—to the place of final deposit. The average depth of the alluvial deposit was 38 feet. About 1,500,000 cubic yards of rock would remain in the channel after the removal of the overlying soil. It was thought that the steam shovel afforded the most economical means of dealing with this rock. A central pumping station was located at a convenient position, in view of the total area to be excavated. Through this region flows the Rio Grande River in a tortuous course. It may be said that here this river crosses the canal at three different points. Two of these are connected by an arm of the river lying almost entirely in the canal. The pumping station is located south of Miraflores Lock and on the west side of the canal and river. There are installed here four Worthington horizontal, direct-acting, triple-expansion pumping engines. These

have 24-inch stroke, 24½-inch water cylinders, and the steam cylinders are of 19, 30 and 50 inches. The pumps are each provided with a surface condenser, together with a single cylinder, 12 x 20 x 24-inch vacuum pump. All the pumps communicate into one delivery pipe. The four Babcock & Wilcox water-tube boilers burn fuel oil supplied from a reservoir consisting of two steel tanks having a combined capacity of 4,000 barrels situated on the hillside back of the station. Each unit has a guaranteed capacity of 7,500 gallons of water per minute at a pressure of 150 pounds per square inch, "with a boiler efficiency of 95 foot-pounds per B. t. u."



MIRAFLORES UPPER LOCKS, LOOKING EAST FROM WEST BANK

The supply pipe from the station is 3,600 feet long. In its first position it roughly parallels the west side of the canal, extending northwards to about the point where the lower locks merge into the widened channel. For 2,000 feet this main has a diameter of 40 inches, and consists of lock-bar pipe. The remaining 1,600 feet are divided equally into two sections of 32-inch lock-bar pipe and 24-inch spirally riveted pipe. All pipe lengths are 30 inches. The thicknesses of the steel plates are those termed Nos. 6, 8 and 10 U. S. standard. There are five air valves and twelve tees. The latter provide connections for the 16-inch spiral riveted pipe of which the distributing lines are formed. The distributing lines are arranged in groups of three, so that two may be in operation while the third is out of commission. The branch pipes lead to monitors, or giants, mounted on concrete barges. These are to be provided with special deflecting nozzles where the pressure of the hydraulic stream is rated at 130 pounds per square inch. These monitors were built by the Joshua Hendy Iron Works, San Francisco, Cal. The Rio Grande was diverted from the scene of operations, but it was also necessary to provide against



GATUN SPILLWAY DAM, EAST COFFER DAM, LOOKING NORTH

water from the Bay of Panama. The supply main is later on to be taken up and run southwards along the line of the canal. There are two positions. For the one, a cofferdam or dike has been constructed across the river bed a short distance below Miraflores Locks.

The general method of procedure as planned briefly is as follows: First, the water north of the dike is pumped out until there is just enough left to support the barges in the lowest situations. The hydraulic efforts of the monitors are then directed against the material lying close around them. This work is continued until the barges sink to the bed rock below. In this way sumps are formed which become the scene of dredging operations. When this preliminary work is done then the monitors begin to undercut and sluice the material to the dredging apparatus. After a time the slope will be insufficient to carry the material. The water is then permitted to rise and float the barges to new points. The dredging pumps deliver into flumes, and these, in turn, carry the water and soil to swamp land in the immediate vicinity. However, the plan was to pump a million cubic yards into the dam on the west side of Miraflores Locks to form the impervious core. It was necessary to install a booster pump in order to accomplish this. This pump is of 20-inch size and connects with 1,200 feet of pipe discharging into the core. The three dredging pumps are 18-inch, single-suction, centrifugal machines, which are directly connected to a 655 horse-power induction motor.

Up to July 1, 1911, there had been excavated from the prism of the canal—on the Pacific end—by hydraulic means a total of 197,677 cubic yards of material. This is, of course, only a beginning. The cost of the work was, on the average, $0.6566 per cubic yard, including ad-

CHANNELED EXCAVATION FOR CURTAIN WALL ON THE WEST BANK OF GATUN LOCK SITE. CUT BY THE SULLIVAN CHANNELING MACHINE

ministrative and general expenses.

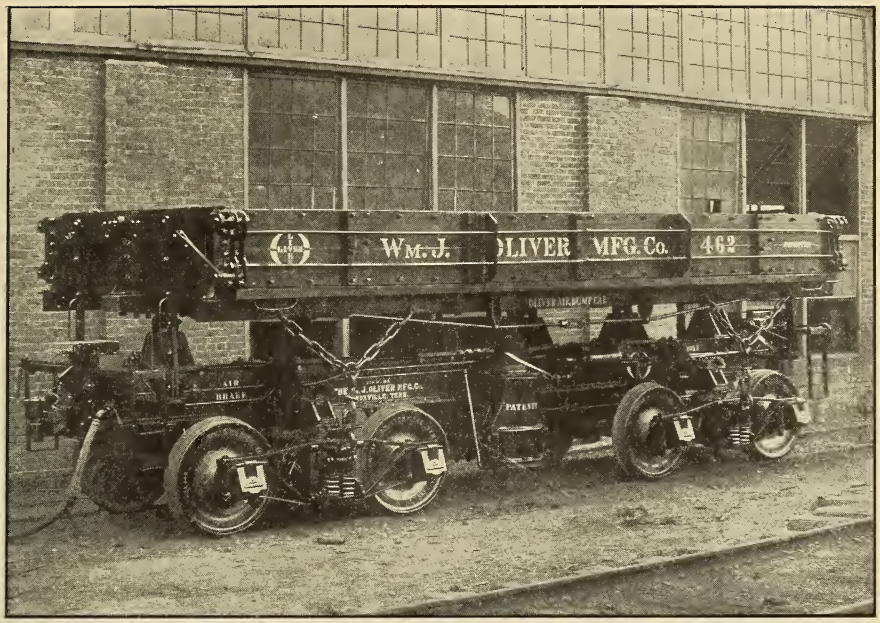
The cost per cubic yard of dredging is, ordinarily, much less than the cost per cubic yard of dry excavation. This is largely due, no doubt, to the fact that the spoil in the one case can be dealt with continuously. When the conditions are equally favourable, however, there is not, perhaps, very much difference in economy. At any rate, this seems to be indicated by a comparison between the costs for steam shovel work and for dredging work at a point near the Atlantic end of the canal. Certain materials were to be removed at Mindi which were similar to those awaiting removal between Mindi and Limon Bay. It was thought that the steam shovel was better adapted for the removal of the one mass of material and the dredge for the removal of the other. The steam shovel performed its work at a cost of about 55 cents per cubic yard. It was, however, charged about 8 cents for dumping, which is, perhaps, proper enough. The dredges excavated the earth at an average rate of 22 cents per cubic yard and the rock at an average rate of 46 cents. But we should add the expense of blasting. When this was done it is found that the expense for dredging rock was 63 cents per cubic yard, and for dredging earth and rock 37 cents.

THE CONCRETE HANDLING

The construction of the Panama Canal involves the very largest concrete enterprise that the world has ever witnessed. For various purposes there will be required a total of about 5,000,000 cubic yards. The mechanical operations involved are many and important. Gatun Locks constitute the largest single piece of concrete construction. Here about 2,000,000 cubic yards will be placed. Other large volumes of this material enter into the construction of Gatun Spillway, the Pedro Miguel Locks, the Miraflores Locks and Spillway.

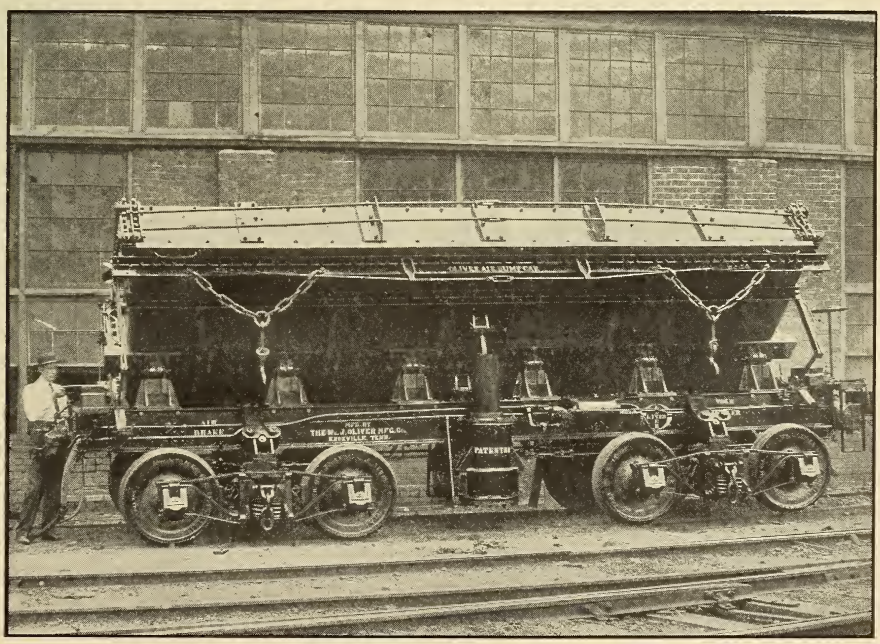
The Portland cement comes from the United States. The sand and rock are obtained on the Isthmus. The great rock quarries—Porto Bello and Ancon Hill—are situated on the coasts of the two oceans. Rock crushed at Porto Bello is transported by boat to the immediate vicinity of the spillway and locks at Gatun. Here it is unloaded and put into storage. As needed, it is withdrawn and transported to the mixing plant. From this point it is, if the final destination is one of the locks, mechanically conveyed, incorporated in concrete, to the distributing cableways. Hand implements have little or nothing to do with the rock after it leaves the crusher—or, in fact, at any time. It is mechanically loaded onto the barges; it is mechanically unloaded from them. It is transferred by gravity onto the cars, which take it from storage to the mixers. The handling of the cement, sand, rock and mixed concrete at Gatun is such an enormous undertaking and involves so much of engineering interest that it will be of interest and profit to consider the general arrangements.

The locks at Gatun are in all six in number—a pair of twin locks at each of three levels. The total lift amounts to 85 feet. Each of the six units is to have a usable length of 1,000 feet and a width of 110. Together with the approach walls, the amount of concrete construction has been estimated at 2,096,000 cubic yards. It will require something over a barrel of cement for each cubic yard of concrete—altogether, about 2,250,000 barrels. The cement is furnished by the Atlas Cement Company, and is manufactured at their plant at Northampton, Pa. It is first shipped to New York, whence it is brought by Government ships to the Isthmus. Barges convey it from Colon or Cristobal to the storage point at Gatun. The terminal channel of the old French Canal is used as a waterway by these barges. The great quarry at Porto Bello is outside of the canal zone, being located



DIRT CAR WITH AIR DUMP APPARATUS. W. J. OLIVER MFG. CO., KNOXVILLE, TENN.

about 17 miles east of Colon on the shore of the Caribbean Sea. The crushed stone is brought from this point by barges. These are towed



OLIVER AIR DUMP CAR IN TIPPED POSITION

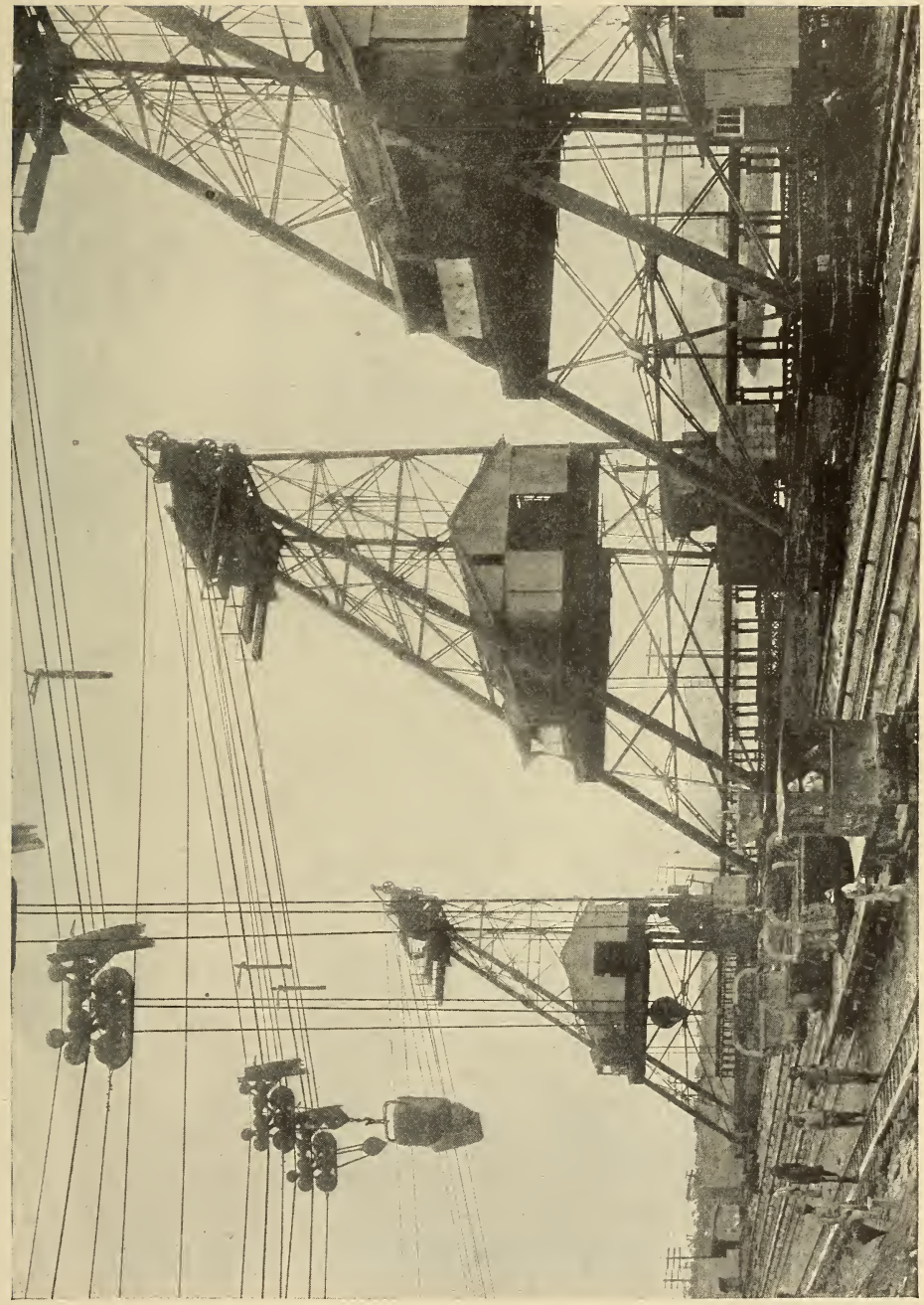
to Cristobal and thence by way of the old French Canal to a storage point at Gatun. The necessary sand is obtained from a still more distant point—Nombre de Dios. This point is a town situated on the coast about 35 miles eastward of Colon. We have an excellent illustration of one of the great advantages of concrete construction. Here is, perhaps, the greatest single piece of such construction; and yet the sand and stone

CEMENT BEING DISCHARGED FROM THE ANCON AT CRISTOBAL INTO LIGHTERS AND TOWED THROUGH THE OLD FRENCH CANAL TO GATUN

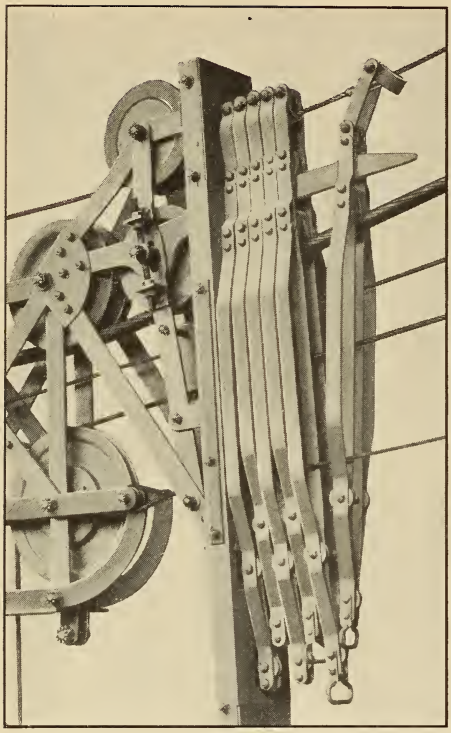
are obtainable from nearby points. In this present case the sources of the materials are so situated as to permit of water transportation to the vicinity of the point of actual use. It is certainly a matter of considerable importance in any engineering construction of great magnitude that the bulk of the material shall be within easy reach.

At the slip where the barges unload there are three Lidgerwood cableways. Two of these are duplex, so that there are really five handling units. On one side of this slip are located the cement shed and the two great sand and stone piles. The shed is close up to the slip, and extends

along nearly the whole of its length. Just back of it are a number of tracks of the Panama Railroad. Back of these, abreast of each other, are the piles of sand and stone. Accordingly, the cableways span the slip, the shed, the tracks and the site of piles. As it is desirable—not to say necessary—that the cableways shall not only command the full width of the place of storage, but also the full length, tracks have been arranged lengthwise of the far side of the slip and of the rear of the sand and stone. Upon these are mounted trucks carrying great steel towers. By operating the towers along the tracks and the cableways between companion towers, all points of the sand and stone storage site are served. The maximum carry of these cableways is 675 feet. Automatic self-digging clam-shell buckets are employed to pitch up the material and to transport it to the point of deposit. The buckets have each a capacity of about 2½ cubic yards. The cement shed is about 490 feet long and 110 feet wide. The transfer of the cement from the barges

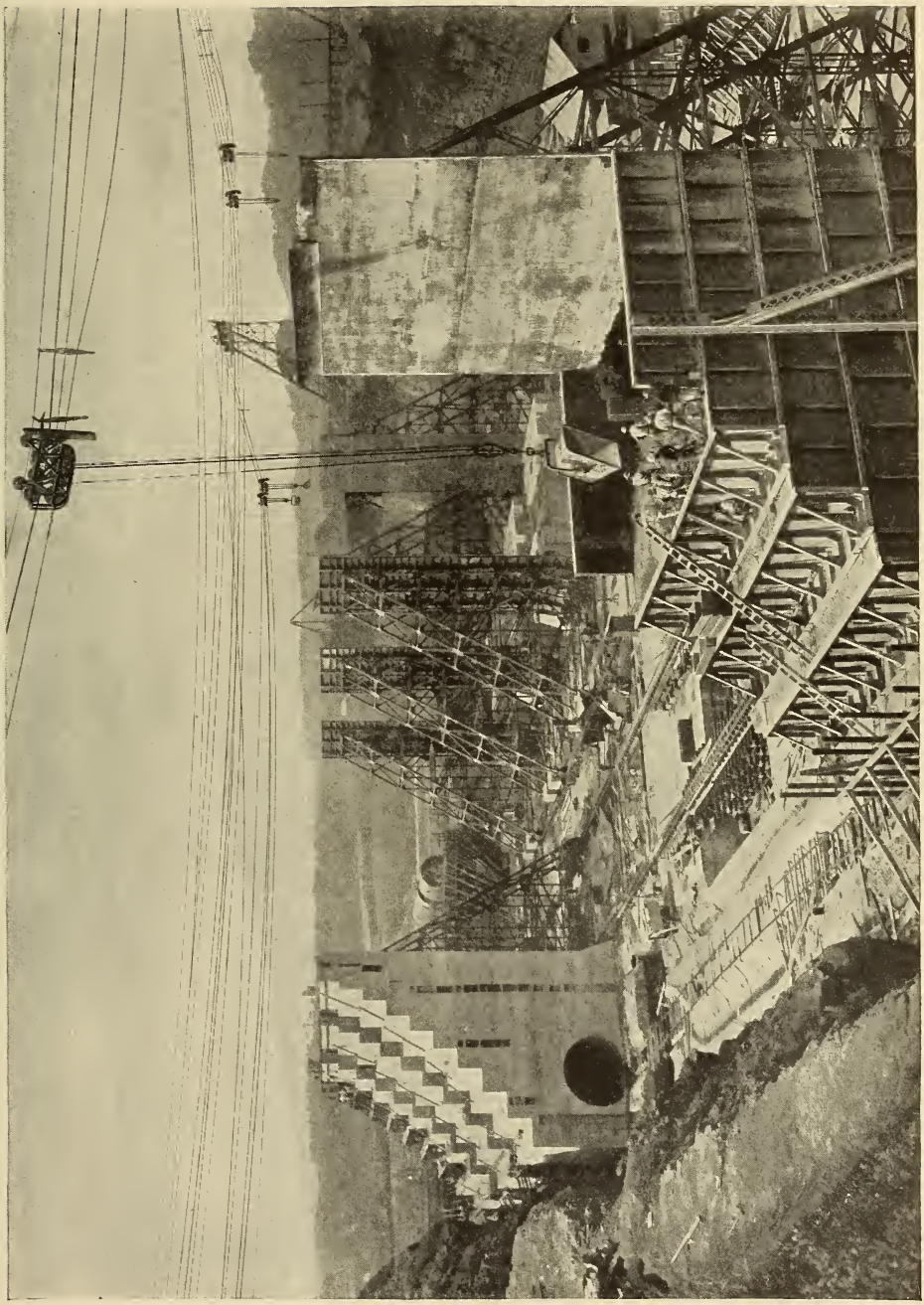


HEAD TOWERS OF LIDGERWOOD CABLEWAYS AT GATUN LOCKS. THE CONCRETE IS BROUGHT BY ELECTRIC TRAINS

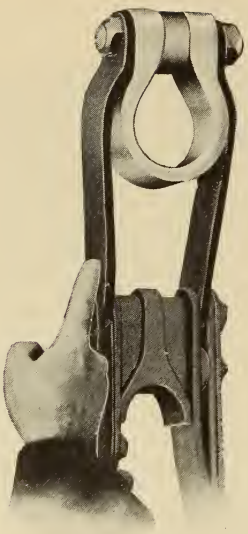


THE LIDGERWOOD SHOCK-ABSORBING CARRIER HEAD WHICH MADE HIGH SPEEDS ON CABLEWAYS POSSIBLE

is effected by traveling cranes. These are ten in number and are of the three-motor type. The cement is deposited in thirty hoppers. These are provided with valves 15 x 30 inches in size. Similarly, the supporting surfaces of the sand and stone piles are provided with valves. Twenty-two 15 x 15-inch valves belong to the sand pile and forty-six 15 x 30-inch valves belong to the rock pile. An electric railway runs beneath the hoppers of the cement shed and is continued on round to pass beneath the piles of sand and stone. By means of the various valves the cars of the railway are loaded with cement, sand and stone in the proportions given by the formula 1.3.6. The railway runs on to the position of the concrete mixers. The plan was to have eight mixing machines. The cars with their loads come up to the mixers, where the tracks run up an incline and secure an overhead position. The ingredients of the concrete are dumped in proper proportions. When the mixing is completed the mixers dump the concrete by gravity into tip buckets. Another railway is arranged which runs along the west side of the lock site. The tip buckets containing the concrete are conveyed on cars running on this track. The cars are moved by electric locomotives. A second set of Lidgerwood cableways are arranged to span the site of the locks and the concrete railway. These are strung from great towers, 85 feet high, which are moved lengthwise of the locks on suitable railway tracks arranged on the two sides. There are four duplex cableways—eight handling units. The cableways take up the tip buckets from the little cars, together with their loads of fresh concrete, and by their combination of longitudinal and transverse movements convey them to the positions on the lock site that may be desired. These cableways have a span of about 800 feet. There are two companion towers to each cableway; the one which moves along on the west bank is the head—or controlling—tower; the one on the opposite bank is the tail tower. A control station is arranged in the head tower. Here the operator controls the movement of his own tower and also that of the tail tower at the other end of the 800-foot span. It is, of course, absolutely essential that the movements of these towers shall be synchronous. All of the operating machinery is located in the head towers. There are three motors to each tower—one of 26 horse-power for the purpose of driving the tower along on its track; another, also of 25 horse-power, which operates the dumping arrangements; and a third of 150 horse-power which drives the hoisting and conveying drums. The tail tower has also a motor of 25 horse-power, which supplies power to operate it on its track. One operator controls all movements. The transverse movement of a load may be



LIDGERWOOD CABLEWAYS PLACING CONCRETE FOR THE CONSTRUCTION OF SIDE-WALL MONOLITHS OF THE UPPER LOCKS AT GATUN



SWINGING EYE AT HEAD OF CARRIER ON LIDGERWOOD HIGH-SPEED CABLEWAY

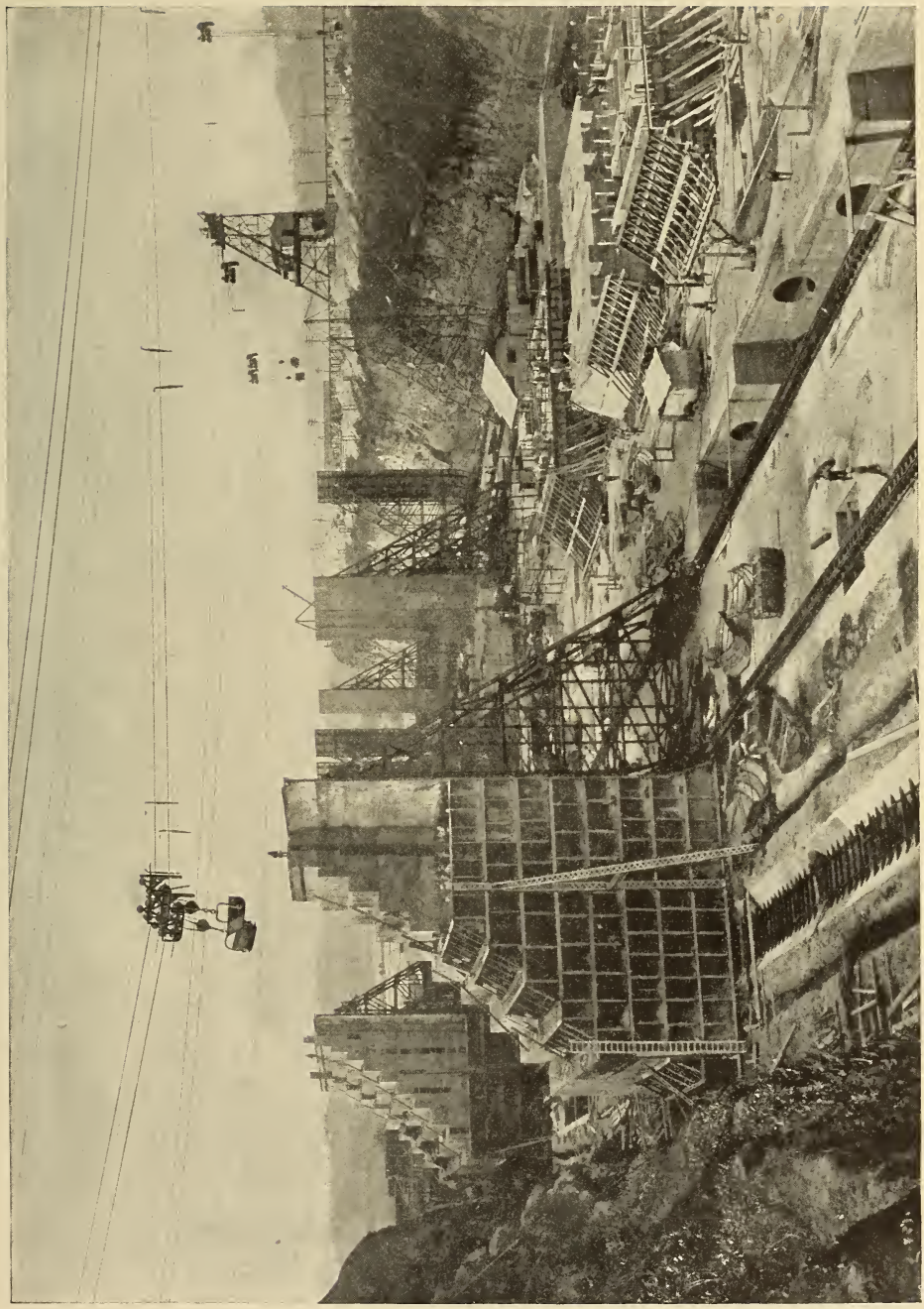
670 feet. The maximum lift is 170 feet. A weight of 6 short tons can be handled. A fixed rope runs from head tower to tail tower. This is a steel cable 2¼ inches in diameter whose outer strands are interlocked together. It is, in effect, a suspended track upon which runs a carriage. This carriage sustains the weight of the load, and its movement back and forth on the cable secures the east and west transportation of the load.

One of the most notable examples of increased capacity and efficiency which has appeared in connection with the demands of the work at Panama upon mechanical appliances is that of the development of the cableway.

In requiring bids for cableways at the Gatun Locks the Government specified that the makers should erect and test the installation on the Isthmus. It was also required that the capacity should be guaranteed, and the usual obligation to make the award to the lowest responsible bidder was included. The questions of erection and testing, although not usually demanded, were entirely capable of solution; but the matters of capacity and of cost required the application of special engineering effort. The capacity of a cableway is a matter which depends upon a number of variables, some of which are not always under control of the builder, such as climate, character of labour, and other local influences. The matter of price was found to be capable of relation to performance, the cost of doing the actual work being made the criterion, so that the engineering problem became one of increasing the capacity of the cableway.

The problem, as thus presenting itself, was taken up by Mr. Spencer Miller, of the Lidgerwood Manufacturing Company, and its successful solution has demonstrated that such undertakings as that at Panama are most valuable stimulants to engineering development. Until the Panama

THE LIDGERWOOD SHOCK ABSORBING FALL-ROPE CARRIER



LOOKING SOUTH IN THE UPPER GATUN LOCK. LIDGERWOOD CABLEWAYS IN ACTION

cableways were constructed the maximum carriage speed did not exceed 900 feet per minute. This speed was limited by reason of the destructive action of impact upon the fall rope carriers and button stops when higher speeds were attempted. To meet this difficulty a new type was developed, in which the impact was distributed over a wider area, while the nature of contact was modified from that of a blow to that of a gradual absorption of the shock. In addition, the carriage bearing sheaves were so connected in a pivoted frame that the weight of carriage and load was always distributed between three sheaves.

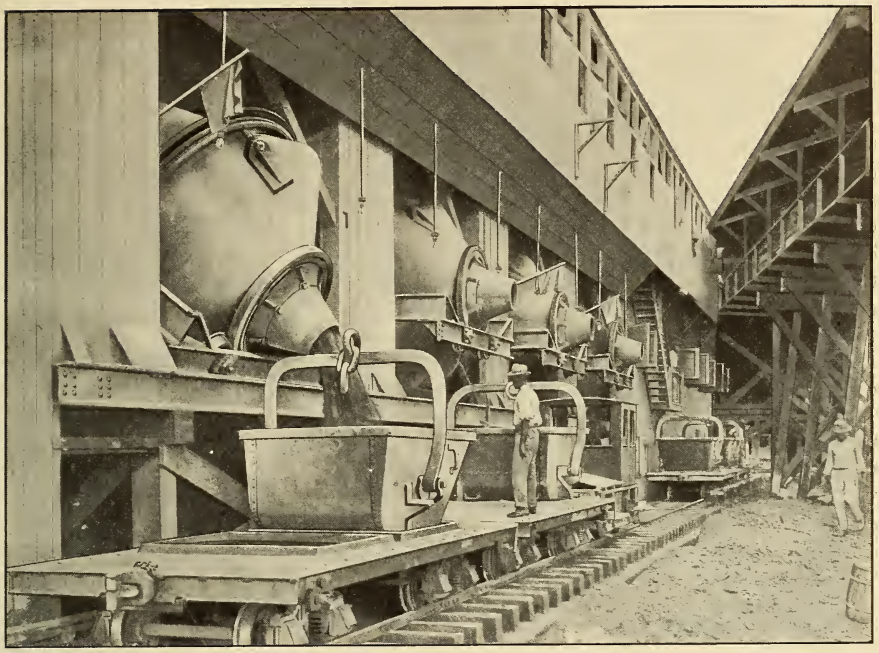
In addition to these radical modifications in the design of the Lidgerwood cableways, there was put into the Panama installation the results of all the lessons which had been acquired during twenty years of experience in this especial department of engineering work. Every pulley over which the ropes were bent was made from 50 to 100 per cent. larger than ever before, in order that the efficiency of the cableways might be reached. The result of this effort appeared in the performance.

Whereas the maximum speed formerly practicable was 900 feet a minute, the builders felt justified in guaranteeing a traveling speed of the load carriage of 1,800 feet a minute, and under test a speed of 3,200 feet a minute was actually attained, while a daily working speed of eighteen hundred to two thousand feet was attained without difficulty.

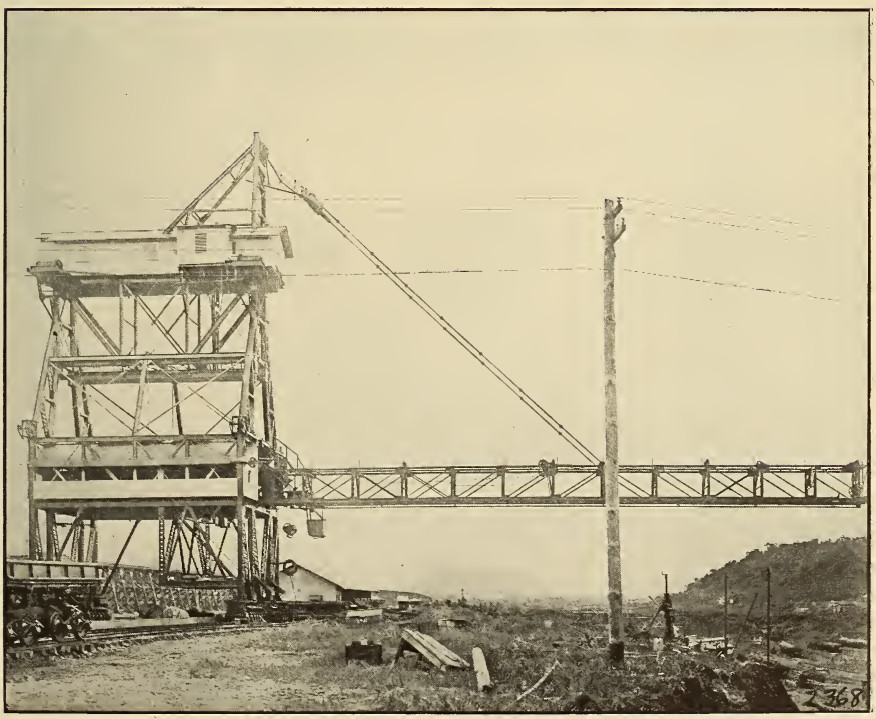
The parts that give out are those simply due to wear, and all the destructive shocks are absorbed in the improved form of construction.

The eight cableways at Panama, laying concrete in the locks, operating twelve hours per day, have lost but one per cent. of the time in shutdowns for repairs from all causes. This means seven and one-third minutes per day. Comparing this with the delays on the Chicago Drainage Canal, which averaged about forty-five minutes per day, working ten hours, this shows a saving of 6½ per cent., or nearly forty-seven minutes in a twelve-hour day. At the cost fixed by the Government engineers of $1.50 per minute for each cableway, this is equivalent to $70.21 per day for each cableway, or $21,063 per year. For the eight cableways this amounts to $168,504 per year. The eight cableways placing concrete at the Gatun Locks were guaranteed to make twenty trips per hour; they have repeatedly made thirty trips per hour. Besides handling the forms which are not moved on their own tracks, reinforcing materials and other articles used in forwarding the work, the cableways were employed in placing the concrete. This averaged, for long periods, about 3,000 cubic yards a day on the Gatun work.

There are two little railroads connecting storage piles and cement shed with the mixing plant. Each of these roads has a gauge of 24 inches and a length of 4,700 feet. The railways are entirely distinct. In case of repairs being needed on one, the other may be used. The material cars are individually driven. Three-phase motors are chain-geared to the axles. The starting, stopping and reversing of these cars is controlled by a master switch, which can be operated from either side. When the switch is moved to starting position, the car starts, and gains its regular speed without further attentions. It makes no difference whether the car moves along on the level or rises on an up-grade—its regulation speed is maintained with very slight variations. What is still more surprising, perhaps, is the fact that the empty cars running down-grade operate their motors as generators, and thus become a source of electric energy for the line. If an accident occurs, automatic brakes stop the cars. Each car has a capacity of about 3 cubic yards. There are two compartments—one for rock and one for sand or concrete. The mixing plant



BATTERY OF CONCRETE MIXERS AT GATUN. MUNICIPAL ENGINEERING & CONSTRUCTION CO., CHICAGO



CONCRETE HANDLING BERM CRANE WITH SINGLE CANTILEVER. WELLMAN-SEAVER-MORGAN CO., CLEVELAND

consists of eight Chicago cube mixers, each having a capacity of about 2½ cubic yards. With the driving shaft running at 180 r. p. m. one operator controls the charging and discharging of a mixer. The machine neither stops nor slows down. The railroad which conveys the mixed concrete to the position where it is taken in hand by the cableways is a four-track line. Two tracks pass to either side of the mixers. A train consists of a locomotive and two flats. One bucket only is carried by a car. When this train has received its load it goes to its destination, where the two full buckets are picked up after the cableway deposits two empty ones. The train is then backed up on the return track and held until its turn at the mixers comes round again. The length of the locomotive is 12 feet, the width 6½ feet, and the height above deck 5½ feet. The wheel base is rigid. The tractive power is 2,000 pounds. Electric motors drive these steel locomotives. There are two for each locomotive—one on each axle. The cars are 18 feet long, 7 feet wide, and have their deck level 2⅔ feet above the rails. Double trucks are used here. The load capacity of each car is about 12 short tons.

Of course, the power plant which supplies the current for the thirteen cableway units, the two systems of narrow gauge railway, etc., is an important detail. Altogether, there are three Curtis 1,500-kilowatt steam turbines of the vertical type. These are base condenser generators. The boilers are of the Keeler type, and were furnished by the D'Olier Engineering Company, of Philadelphia. There are six of them, arranged in batteries of two each. The boilers are rated at 400 horse-power each. Foster superheaters are employed. When installing this plant it was planned to use crude oil as fuel. The furnaces are, accordingly, very large. In order to provide for emergencies, they have also been fitted with Ajax shaking grates, so that coal may be used.

NOTE.—In the title of the lower illustration on page 340 of the April issue, the double cantilever crane was built by the Wellman-Seaver-Morgan Company, and not by the Brown Hoisting Machinery Company, as stated.

(To be concluded.)

WIRE MESSAGE RATES

By Wm. W. Mulford

THE determination and maintenance of reasonable telephone and telegraph charges is of moment and of personal interest to most of us.

We have learned that "the luxuries of yesterday are the necessities of to-day," and in this way the telegraph and the telephone have come to be necessities. Furthermore, it has often been said the wire service is a natural monopoly, and we recognize that, of all the great industrials, the wire service business holds a unique position in two respects: First, for any extensive wire system, either telegraph or telephone, the one not only supplements and sustains the other, but also the one is the by-product of the other; for economy and efficiency they should be combined. Second, we do not want the annoyance and inconvenience of two telephone systems, and we do want a universal system. Briefly, we want a monopoly, provided we can have a sound guarantee of satisfactory service at reasonable rates.

Therefore, in seeking a basis for reasonable rates, and in order to eliminate quibbling arguments, it is safe to take a look ahead—it may not be a far distant glance even so—and assume that competition no longer exists in the wire service business.

It seems curious that in the art and craft of salesmanship man has so far devised only three basic methods. The first method is known as "good business," or "charge what the traffic will bear"; or "commercial expediency," or "charge according to the value of the service." The second method is known as "charge according to the cost of the service," either with or without an agreed fixed percentage for "the knowing how," sometimes called supervision. The third method is a low, fixed price, with a government backing of ample strength to make up the annual deficit in case it is required.

Under the first method rates are regulated by competition, by the law of supply and demand, and by the Golden Rule. When monopoly appears, competition ceases; the law of supply and demand takes an unusual form, in that there may be difficulty in raising money to provide for the essential increasing development that is to furnish the "supply," and in that it is easy at any time by unreasonably high prices to check the "demand," otherwise this law is ineffective; and to depend upon the Golden Rule, even in the twentieth century, is akin to leaning on a reed. Under the second method the great Boston gas case was solved successfully whereby, briefly, a franchise was granted requiring that gas of standard quality be furnished at a fixed price, this price to be just enough above actual cost to permit the owners of the plants to receive a trifle over the usual savings bank returns on their money invested, and that the owners must reduce the price of gas five cents per thousand for every one per cent. they would be permitted to increase their dividends. Under the third method competition was barred by law and the government assumed the monopoly. To prove that the charge of what the traffic would honestly bear was a rate so low that in comparison with the then current rates seemed absurd was the great work of Sir Rowland Hill, and upon the principles he in-

troduced the mail service of the world is handled to-day.

Another method for regulating rates has been suggested—that of maximum prices fixed by legislative enactment. If this plan were in force, obviously the monopoly would charge the full price—that is, the maximum—if the traffic could be made to bear it, regardless of changing conditions; the minimum and maximum charges would be the same, and would rarely be lowered, except by further legislative enactment. Such a plan places a high premium on legislative control.

Massachusetts arranged that where railroad securities earned over a certain fixed percentage all earnings above that should be paid to the Commonwealth. It was not effective. The books and capital stock were kept in such a manner that the roads were never allowed to show that they earned so much. In brief, the railroads without any difficulty "got around" the law.

Following the assumption that the wire service is a monopoly and that it is desirable to have it a monopoly, in order to regulate rates it is necessary to discover and experiment with some new plan or to follow one of the methods stated.

If we follow each of the three methods to its logical conclusion:

The first method obviously with the recognition of monopoly becomes ineffective, and does not require further consideration.

The second method suggests a plan which, outlined briefly, is to assume that the present charges are reasonable; to accept the present capitalization as an honest and full valuation of their property, organization and "going concern"; to accept a rate of interest 1 or 2 per cent. higher than the average savings bank rate of interest as a just rate; to permit an increase in this rate when it is accompanied by a certain fixed percentage decrease in rates for service and a certain fixed percentage increase in the wages of employees. In considering such a plan it is necessary to provide for means of increasing the size of the plant in order to meet the annual increased development, and to guard against "loopholes" aimed at sacrificing the quality of the service in order to show quick results, and leakages, as, for instance, the purchasing of supplies at exorbitant prices from an inside clique.

The third method would either require government ownership of the monopoly or government recognition and protection of the monopoly, provided it put into effect low rates based, as far as possible, on the principle of mail service rates.

In this connection it is important to recognize that while we have discarded competition in this article and accepted the principle that the wire service of this country should be under one management, and while at the present day there may not be sufficient competition, except in very few localities, that is worthy of the name, nevertheless the monopoly apparently holds a certain fear of possible competition that it has never so far been able to shake entirely off. This fear or dread is of ample strength to make it an item of large consideration in trading with the government for the privilege and strength of being a recognized and protected monopoly.

Service first and reasonable charges second, is the demand of modern business—"commercial service," as it is called by the trade. A method of regulating rates whereby a recognized and protected wire service monopoly will provide commercial service and charge only what the traffic will honestly bear is the problem before the wire service monopoly. The problem is solvable. Furthermore, it is for them rather than for their vast army of customers to offer the solution, since its consideration is for the good of the service.

LESSONS OF THE "TITANIC" DISASTER

By Henry Harrison Suplee

THE appalling disaster of the loss of the *Titanic* is bringing forth a number of possible explanations of the complete failure of this, the latest example of marine architecture and engineering, to meet the forces of the sea; but it is probable that the detailed facts will forever remain with the ill-fated vessel in the depths of the Atlantic.

Without attempting to discuss this side of the case, it may be permitted to indicate some of the lessons of the disaster as applicable to vessels now in service and under construction.

The time-worn query as to the result of impact between the irresistible force and the immovable body, while not absolutely exemplified in the collision of the *Titanic* with the iceberg, was yet sufficiently reproduced to furnish a reply after a kind. Doubtless the iceberg was broken and damaged at the portion of contact, but its injuries were barren of results, and all the real loss was borne by the artificial projectile, with its burden of living and material value. That such a thing could occur at all is a matter for investigation and controversy, probably coming sufficiently long after the event to be barren of results. Rather let us examine here what is to be done now to render ocean travel free from the possibility of a recurrence of any such piece of helpless inefficiency.

In the transport of passengers across the ocean there are three things to be considered broadly:

1. Safety.
2. Comfort.
3. Speed.

Each of these may be expanded into a number of details, but it cannot be doubted that their importance lies in the order given. To secure either comfort or speed, or both, at the expense of safety is a situation which no steamship line would willingly announce, and which no passenger would willingly accept. That safety has been sacrificed to speed, and even to luxury, appears altogether possible in the light of the recent disaster. So far as speed is concerned, considered as the time occupied by the voyage as a whole, there is no doubt that the loss of time involved in making the detour necessary to avoid the ice pack altogether would have made the disaster impossible. So far as luxury is concerned, the use of the ample space given to recreation would have permitted a sufficient number of boats to have carried every soul safely away from the sinking hull.

Taking, then, safety as the prime consideration in the construction and operation of a vessel, we may examine some of the points in which this most important of all features must reside.

The strength of the hull itself has generally been given much consideration, but it is a matter for examination as to whether the increase in strength has kept pace with the increase in size of vessels built in the past decade. To make the proportions of such a vessel as the *Titanic* governed by considerations growing out of experiences with smaller ships is to make much the same kind of a blunder as was made in connection with the Quebec bridge and to invite a similar disaster. Probably no marine architect would undertake to design a hull which could be expected to withstand the impact force existing at the instant of contact with such a mass of ice as stood in the

way of the *Titanic;* but, assuming that such a blow may be given and that the outer hull is penetrated, the full magnitude of the subsequent forces to be resisted in order to insure safety may be intelligently considered.

The development of the system of watertight bulkheads has demonstrated the correctness of the principle. It is entirely possible to divide the interior of a vessel into compartments of such size and disposition that the rending of the hull shall not admit sufficient water to sink the ship, and the effectiveness of such bulkheads has been demonstrated by a number of actual experiences. To be effective, however, the bulkheads must be capable of replacing the damaged hull behind which they stand and serve as effective bulwarks between the passenger and the sea. That such was not the case with the bulkheads of the *Titanic* appears to have been the fact; how much dependence may be placed upon similar bulkheads in vessels of similar size and construction has not been actually determined, and when the test comes it may be too late.

It is evident that bulkheads which are sufficiently strong for vessels of moderate dimensions are not very reliable sources for data in designing similar partitions for much larger ships. To secure both strength and tightness, it should be possible to determine the actual stresses beforehand and build accordingly. It is not to be presumed that any bulkhead could resist a direct blow capable of penetrating the hull, but the time and space between the first and second blow should make the latter much lighter than the initial impact force.

In any case, the number and location of bulkheads should be such that the failure of several compartments would still leave the hull with sufficient buoyancy to keep afloat. It is evident, however, that the partition or bulkhead which is to serve for some considerable time in the place of the wall of the original hull as the barrier between the passengers and the waters must be so strong and stiff that it will be truly dependable.

Considered in this light, it is axiomatic that as much attention should be given to bulkhead construction as is already given to the hull itself. The bracing which this involves will probably encroach somewhat upon the space desired for other purposes, but no other purpose can possibly be of such commanding importance. Possibly the double cellular construction similar to that used for the double bottom may be found adaptable in place of framed bracing, or as auxiliary to it; but, in any event, the bulkhead should be considered as an element in the design equal in importance with the main hull itself, unless safety is to be subordinated to some other consideration. There is little doubt that the passengers would willingly appropriate to this element the amount expended upon gymnasiums, swimming pools, golf links and garish decorations.

There appears, then, as the first lesson from the *Titanic* disaster the fact that the strength, stiffness and general design of the interior partitions, bulkheads, doors, and all that go to make up the provisional hull in case of collision should be considered as a part of the hull itself, and be capable of replacing any damaged part beyond.

It is not assumed that even the utmost strength of construction can furnish absolute protection against shipwreck, and hence the provision of sufficient boat capacity to receive every soul on board is a matter of absolute necessity. It is evident that this feature in its present condition is antiquated, and the modern great ship, with a boat equipment of a score of years back, is in itself a condemnation of the existing system of ocean transport, so far as safety is concerned.

Not only is the number of boats

wholly insufficient, but the boats themselves are fit subjects for a nautical museum. There is hardly a rough fishing dory on the coast of New England which has not, squatted down in its stern, a little chugging motor, rendering it independent of wind or oars, and bringing it under control of a single man or boy. The upper promenade deck of the *Titanic* would have been a welcome place on that Sunday night had it contained forty or fifty such motor boats, and yet their cost might readily have been squeezed out of the decorator's bill.

Taking up the second element in ocean transport—that of comfort, considered in relation to safety at sea—there appears to be no reason why the fullest comfort should not be compatible with safety. It is not for a moment assumed that any proper safety device has been neglected because of the additional cost involved, and there is every reason to believe that if the builders and owners of the *Titanic* had not believed that the vessel was "unsinkable" they would have given her a different equipment and followed a different route than they did. It is now demonstrated, however, in an unanswerable manner that such a ship is not safe, and that several vital elements which would have added greatly to the safety of her passengers might have been included. The past is past, and the *Titanic* lies at the bottom of the Atlantic, with more than a thousand souls drawn down with her. To permit any similar vessel to enter or continue in service in a similar manner is to render possible a repetition of the disaster. There is here opportunity to put into immediate effect the facts brought out by the loss of the *Titanic,* both by critical inspection of the bulkhead construction of existing vessels and by the introduction of such bracing and strengthening as may be found necessary. For vessels now under construction the opportunity to meet the conditions before which the *Titanic* failed is one to receive the amplest attention. The question of the cost of doing this, if given any consideration at all, may be taken up with the advisability of curtailing the expenditure originally intended to be given to those elements of luxury which do not really add to comfort. It is not too much to say that the desire to make the modern first-class liner a gaudy palace is not due to the demands of the passengers, the greater portion of whom are wholly indifferent to the ornate work of the decorator, and desirous only of receiving the benefits which accompany restful quiet and freedom from distraction. The competition which has been the cause of much of the lavish expenditure upon recent vessels may be traced to the desire of the various steamship lines to offer assumed attractions to passengers, and the reason for such display may readily be understood; but there is every reason to believe that the vessels which hereafter are able to show marked advances in safety of construction, equipment and operation will be offering far greater inducements to passengers than those which maintain silence upon these points, while displaying less material inducements.

The elements of comfort which may well be obtained with such reduction of cost as would leave ample funds for expenditure upon greater safety are those including, above all, swift, courteous and efficient service. Freedom from distracting noises; absence of petty annoyances; gentle, prompt and thoughtful attendance, together with such wisely selected food as is known to be appropriate for the conditions of life at sea—these are the real elements of comfort which, broadly announced and faithfully supplied, would draw to the vessels more and more the passengers who will hereafter scan, more critically than ever before, every detail of the ships to which they intrust themselves.

The comfort of many persons is closely allied to the frame of mind in which they exist, and no material display can take the place of nervous uncertainty and continual apprehension. Here is a point at which safety and comfort come very closely together, and there is little doubt that real assurances of continual care for safety would conduce far more to the comfort of every passenger than unfounded and unwarranted assertions about the "unsinkability" of the ship. This means that an important element in the comfort of the passengers lies in the plain evidence of safety precautions and apparatus. Visible indications of massive construction will hereafter be more welcome than ornamentation which conceals the construction; and, properly treated, such a plan will be found to be in better artistic taste than ornamentation which bears no relation to construction. The presence of an abundance of apparatus for leaving the ship in case of disaster may act to quiet the nervous passenger far more effectively than any verbal assurances that disaster cannot occur. The full efforts of engineers and inventors may well be directed toward the production of boat equipment which shall represent the latest state of the art of small motor boat construction and operation, and the apparatus for immediate operation of the full boat equipment should be in daily evidence in a sincere and reassuring manner. Such obvious and honest treatment of the question of safety, widely announced and faithfully lived up to, may surely be indicated as a wiser method of attracting passengers than broad generalizations about size, speed and luxurious appointments.

Safety, therefore, comes first; but without visible assurance that everything possible is being done for safety the second element—that of comfort—can be very imperfectly supplied.

The third element—that of speed—is closely connected with both safety and comfort. The demand for high speed across the Atlantic has come, not so much from the passengers as from the competition between the various lines for the possession of the "blue ribbon," itself little more than a vain cry to attract attention. It is well known that maximum speed is attained only at disproportionate cost of power, and that it is only by mail subsidies and similar compensation that the highest sea speeds now possible can be paid for. The passengers have not demanded such speeds, and in many cases they have not reaped the advantage, such as it is, of the few hours' gain in time, often being obliged to wait in port or to arrive during inconvenient night hours in the wild scramble after speed records.

Experienced travelers across the ocean are thoroughly familiar with the personal inconveniences to which they are subjected in the desire of the steamships to make high speeds, and the vibration, bustle and discomforts of the fast liner are wholly unwelcome to the seasoned traveler, who, whenever possible, seeks the vessel of moderate speed, under the control of the quiet, conservative commander, entirely willing to take the safer route rather than the shorter cut, and as considerate of the comfort of his passengers as of the commercial interests of his employers.

The northern, or shorter route between New York and the British ports, is nominally used only during those months in the year in which no danger from ice is to be expected; but the experience of the *Titanic* has shown how futile such expectations may be, and this has fully demonstrated that under no circumstances should the northern route be used during any time of the year. The lessons are obvious, and it is to be hoped that they will not be soon forgotten.

CONSTRUCTION FEATURES OF THE WATERVLIET SHOPS OF THE DELAWARE & HUDSON COMPANY

By O. D. Lee

THE tendency of large companies to locate their plants outside the crowded limits of great cities is more strongly marked each year. The day of dark, poorly ventilated and crowded shops and manufacturing plants is passing, the conditions of workmen being greatly improved thereby, and more and more it is being realized that hygienic conditions, pure air, good light and healthy surroundings are important factors of increased efficiency.

The recent organization of the Efficiency Society, which started its work with about one thousand members at its first meeting in February last; the standing of its charter members, men who are leaders in all branches of industry, and the enthusiasm displayed by them individually and collectively in the objects of the Society, emphasize the thought now being given to the necessity of increased efficiency and the fundamental factors required to obtain the desired result.

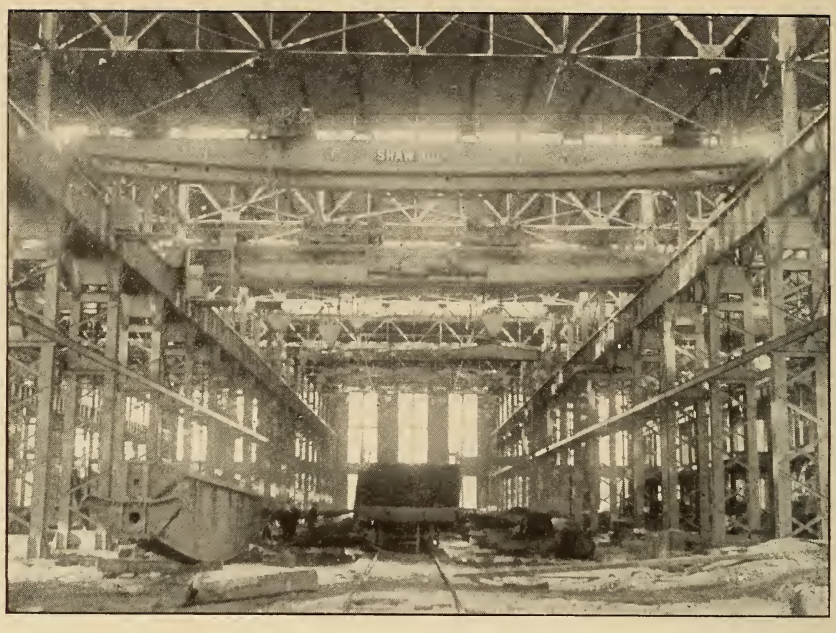
A striking example of well planned and carefully constructed shops is afforded by the new plant of the Delaware & Hudson Company at Watervliet, N. Y. In May, 1911, one year ago, ground was broken for these new shops, fifteen in number, constructed on 163 acres of land south of the Watervliet Arsenal, and by July, 1912, it is expected that they will be in full operation.

These extensive works were laid out by Mr. V. Z. Caracristi, consulting engineer of the Delaware & Hudson Company, and the same gentleman has also had charge of their construction. The plant will be the largest in New York State devoted to the same purpose, will cost $2,000,000, and will be equal to any in the East.

This entire plant is new, and in building it advantage has been taken of all the good points of the leading shops now in use throughout the country. No special effort has been made toward architectural effect, but the plant is in every way the last word in so far as handling the work is concerned, and in the provision for good ventilation and as much light as possible. In connection with the latter it is of interest to note that the amount of glass in these Watervliet shops can be expressed by three acres.

The largest of the fifteen buildings is the locomotive repair shop, 510 x 387 feet, covering four and one-half acres of ground. When completed, these shops will enclose under cover more than eight acres of the property, and there will be more than twenty miles of track on the ground.

There are fifteen carrying cranes, which were built by the Shaw Electric Crane Company, of Muskegon, Mich. The largest crane for handling locomotives has a capacity of 150 tons with two trolleys, one of the trolleys carrying a 10-ton auxiliary hoist, and two other cranes for the same purpose, having a capacity of 100 tons each, which are also two-trolley cranes and are equipped with one 10-ton auxiliary hoist. There is one 30-ton crane, 55 feet span; one 25-ton crane, 20 feet span, and two 15-ton cranes, with 47 feet 6 inches span. There are seven cranes of 10 tons capacity each, one with a



LOCOMOTIVE REPAIR SHOPS, DELAWARE & HUDSON COMPANY, SHOWING SHAW ELECTRIC CARRYING CRANES

span of 100 feet, three with a span of 65 feet, and three with a span of 55 feet; and two cranes of 5 tons capacity each, having spans of 85 feet and 67 feet 6 inches.

All these cranes are of the Shaw Company's latest standard design, and, in addition to these cranes, the same company is furnishing two locomotive pullers with a capacity of 2,500 pounds each.

The special features of construction are as follows:

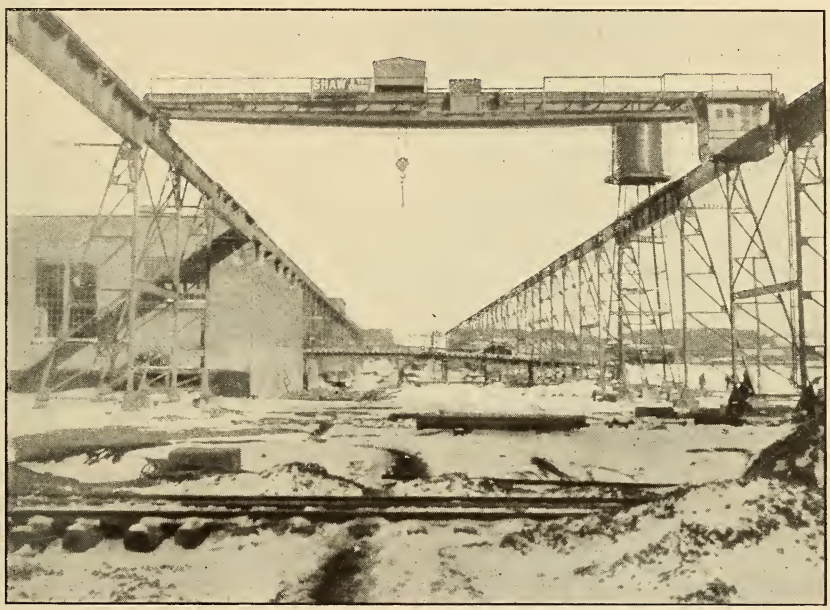
The locomotive repair shop differs from the ordinary type of traverse shop in so far as a 150-ton transfer crane, built by the Shaw Electric Crane Company, has been substituted for the usual transfer table and pit, this crane being under roof. The space usually made unavailable by the transfer pit is, in this case, utilized for the sorting of material, location for pipe gangs, etc., and it is not necessary to lift a locomotive except high enough to clear the material stored in this bay, such as driving wheels, etc.

The locomotives are dismantled on the incoming track and transferred by means of the 150-ton crane, placed on lorry trucks and pulled into the erecting bay by means of portable locomotive drags operated by a motor, suitable plugs being provided for the power in the columns supporting the runways. After the erecting work has been completed, the wheeling is done in the erecting bays, for which purpose 100-ton cranes have been provided.

After wheeling, the locomotives are dragged back into the transfer bay and lifted over the material lying on the floor to the outgoing track, where the finishing-up work is done, and the engine run out under her own power. It will be noted that this shop has been provided with a very complete equipment of cranes, light cranes being provided in each bay for the handling of miscellaneous material, and, where necessary, heavy cranes for special work.

A portion of the easterly bay is used for a tender shop, and the south end of the erecting and transfer bays

are used for boiler shop work. The galleries will be used for light machine work, painting, etc., thus making the locomotive repair shop practically a complete unit in itself, all work necessary for repairing locomotives being taken care of in this building, with the exception of the hammer work, requiring open fires, which work will be taken care of in the hammer shop building immediately next to the main shop, this building being 158 x 68 feet.



SHAW ELECTRIC CARRYING CRANE, DELAWARE & HUDSON COMPANY, WATERVLIET, N. Y.

As a substitute for the usual lye vats, this shop has been provided with a locomotive washing-off table, where the complete engines will be thoroughly washed down with hot water under pressure; by this means most of the dirt and grease can be removed from the parts cheaper and with equal satisfaction to the lye vats and without the usual objection to the operation of either open or closed lye vats, which objections are nearly all of a character as to almost entirely make the lye vats useless.

In connection with the plant an iron foundry of 20 tons per day capacity has been provided of the most modern design. The gallery floor is used for the storage of charges for the cupola and the complete brass foundry. An interesting feature in connection with the foundry, brought about by the modern tendency for the use of cast steel, is a small converter plant of two tons per hour capacity, which will be ample to take care of the requirements of the railroad, in so far as small steel castings are required. The complete foundry equipment for this building was furnished by the Whiting Foundry Equipment Company, Harvey, Ill., and includes, among other equipment, a No. 5 Whiting cupola, diameter of shell 60 inches, height 67 feet 8 inches; No. 3 Whiting cupola, diameter of shell 46 inches, height 67 feet 8 inches; core and drying ovens, and complete line of ladles up to 5-ton capacity. Equipment for brass foundry and steel foundry has also been furnished by this firm.

The storehouse building, which is 101 x 62 feet and four stories high, is provided with every facility for

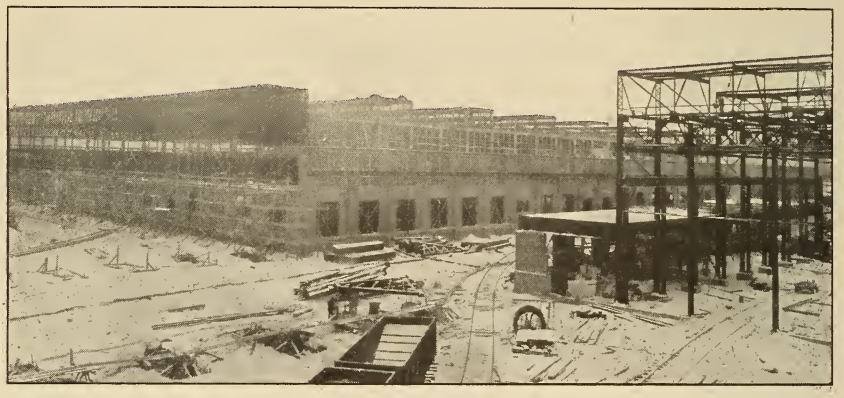
the economical handling of the material, and will be used not only as a source of supply for the shops, but will take care of the stores for the northern division of the railroad. The second story of this building will be partially cut up into offices for the superintendent of shops and his force, together with an apprentice instruction room, the Delaware & Hudson Company having a very complete and efficient system of instruction for apprentices, consisting of an elementary course of arithmetic, drawing, etc., which instruction is taken care of by a competent chief, the course being compulsory, and the apprentices being paid for the time devoted to their studies.

In this building are also provided fireproof vaults for the storage of important records and material.

Between these two buildings and extending both north and south is a 100-foot-span yard crane runway served by a 10-ton-capacity crane, which will provide facilities for handling the storehouse material for the service of the gallery of the iron foundry, a platform being provided for this purpose, and for the distribution and handling of heavy scrap material to the casting drop, which will be located under this crane.

A complete system of facilities for handling material from the storehouse casting platform and storehouse building to the main shop building is included. The economical handling of both the finished and rough parts is amply provided for, and the equipment in the repair shop building will all be located and in line with the most modern practice in this direction.

These shops being located at a point midway between Albany and Troy, all passenger trains will be cleaned and made up at this point, for which purpose a 30-stall round-



DELAWARE & HUDSON SHOPS AT WATERVLIET, UNDER CONSTRUCTION

house has been designed and erected. This roundhouse has a 20-foot extension covering five bays, for the purpose of providing space for the equipment necessary for light repairs and doing away entirely with the necessity of interfering in any way with the heavy repair work being done in the repair building proper. This roundhouse is provided with direct steam heat, the coils being placed in the pits and on the walls.

The washing and refilling of boilers are taken care of by a complete system which was installed by the National Boiler Washing Company, of Chicago, which allows a boiler to be emptied in thirty minutes and designed so as to allow three boilers to be washed out at one time, a feature of this system being that it provides for the saving of the greatest amount of waste heat blown out of the locomotives. In this in-

stallation the pumping equipment and tanks are located in the power plant pump room.

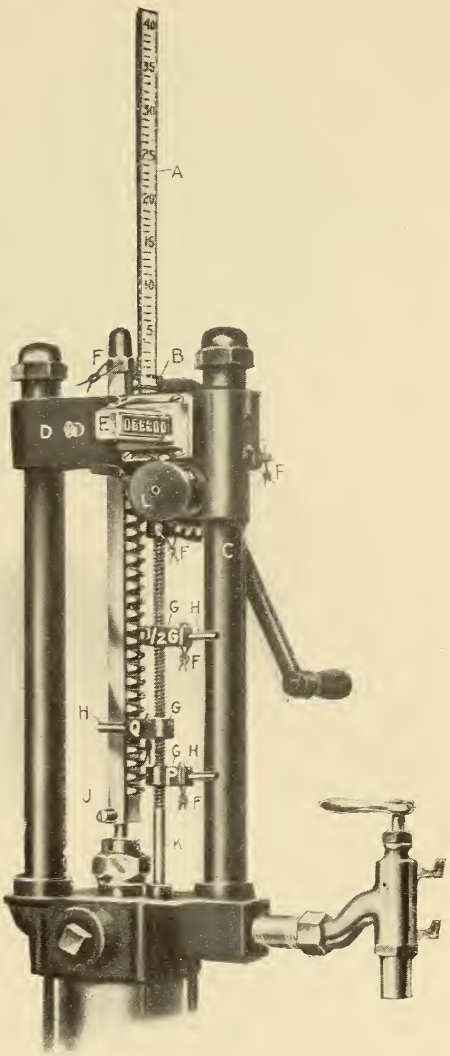
The roundhouse is lighted by incandescent lamps placed between the stalls. The turntable is 90 feet long and provided with a power tractor made by Nichols Brothers, of Chicago, and is of the heaviest type, capable of handling any locomotive on wheels. As the Delaware & Hudson Company has locomotives of the highest tractive power in service on the southern end of their lines, in view of the possibility of these heavy engines being used on the northern end, the required facilities have been provided to take care of them at this point should it be necessary in the future.

Provisions for cleaning engines is provided for in two ash pits, cross-section of which is given, the necessity for the large ash pit facilities being brought about by the exclusive use of anthracite coal on the Delaware & Hudson Railroad.

The coal pockets are of the incline approach type, the cars being hauled up by an electric hoist, which was furnished by the Fairbanks-Morse Company. These pockets are provided with a storage capacity of 600 tons, and the coal delivered to the locomotives is measured, the measuring device being furnished by the Gravity Measuring Coal Chute Company, of Washington, D. C.

The terminal is provided with grill storage tracks for outgoing locomotives, arranged to take two locomotives on each track, so as to permit any engine to be handled without interfering with the others.

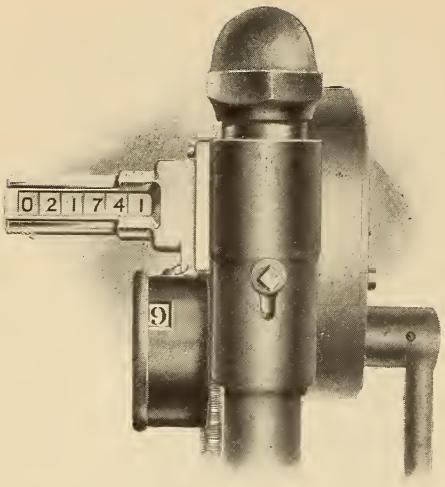
The roundhouse terminal is also provided with a very complete oil house of reinforced concrete and brick, 61 x 34 feet, with basement, in which not only all the oil for the engines will be kept, but provisions have been made by means of tanks of large capacity to take care of the fuel oil for the entire plant, the oil house having a storage capacity in total of over 45,000 gallons of oil.



COMPUTER OF GILBERT & BARKER OIL PUMP

The Gilbert & Barker oil storage system has been installed, and is a model plant of its kind, consisting of twelve storage tanks, ranging in capacity from 65 to 12,000 gallons, and twelve measuring pumps.

The tanks containing the lubricating and illuminating oils are placed in the cellar of the oil house, while the tank containing the gasoline is situated at a point 10 feet distant from the building, buried underground, where the gasoline is kept



GALLON METER AND DISCHARGE REGISTER ON OIL PUMP

at a passive temperature. This tank is filled from a special filling cap directly above the tank. The other tanks are filled from fill boxes, which are set flush with the oil house floor. Barrels, when placed on special filling devices over these fill boxes, drain their contents automatically into the respective tanks.

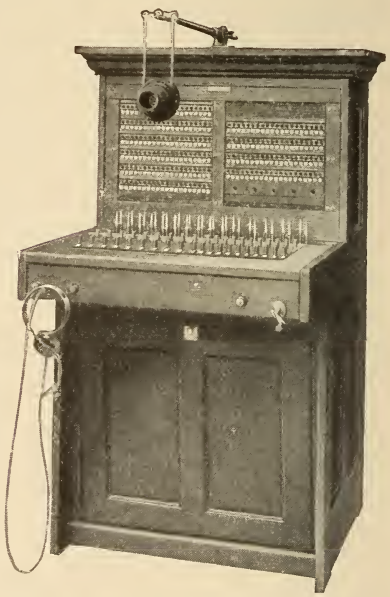
The accompanying table shows the various kinds of oil handled:

No.	Capacity.	Contents.
1	10,000 Gal.	Kerosene Oil.
2	12,000 "	Fuel Oil.
3	10,000 "	Car Oil.
4	2,500 "	Signal Oil
5	2,500 "	Valve Oil.
6	2,500 "	Mineral Seal.
7	500 "	Engine Oil.
8	200 "	Linseed Oil.
9	120 "	Cylinder Oil.
10	65 "	Air Brake Oil.
11	65 "	Dynamo Oil.
12	500 "	Gasolene.

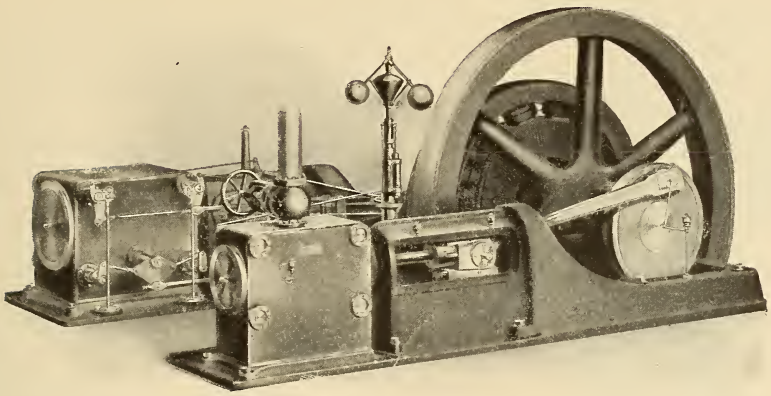
Tanks Nos. 1, 2 and 3, containing kerosene, fuel oil and car oil, are of sufficient capacity to contain a carload at a time. Therefore, an extra filling connection is run from each of these tanks so that tank cars may be coupled directly to them. All of the tanks are provided with properly graduated gauge indicators, which enable the storekeeper to know when his oil supply should be replenished. All of the tanks are vented above the roof of the oil house. The gasoline tank is vented separately above the roof of the building.

The pumps are the latest Gilbert & Barker self-measuring, single-action type of gallon capacity. They are so arranged that fractional parts of a gallon, from one-quarter of a pint upward, can be discharged accurately into receptacles without the use of measures or funnels. The quantity stops that determine these fractional parts of a gallon are swung on a threaded rod, thus insuring permanency of position and the subsequent accuracy of quantity. The accumulative amount of liquid discharged from each pump is recorded on a meter placed on the pump head. This meter records all liquid pumped, regardless of the amount at one operation or any number of operations up to 100,000 gallons. This enables the storekeeper to have an accurate check of all oil delivered upon requisition.

The pumps are so situated on the floor that all the valves governing the suctions of the pumps are accessible. Each valve can be removed, cleaned and reground, if necessary, and set back in place



TELEPHONE SWITCHBOARD, WESTERN ELECTRIC CO.



HORIZONTAL CORLISS ENGINE, C. & G. COOPER COMPANY, MOUNT VERNON, OHIO

without disturbing the suction line in any way.

Each pump is provided with a return connection leading from the bottom of the drip pan, which is set beneath the nozzle of the pump, to its proper tank. All oils spilled accidentally are conducted to their respective tanks, thus eliminating waste. The gasoline tank, No. 12, has no return connection, as this would introduce gasoline vapours into the building.

The functions of the oil storage system as described above are:

First. To provide an adequate storage for oils.

Second. To obtain the maximum storage at the minimum risk.

Third. To provide a means of delivering the various oils in accurate quantities and without excessive labour charges for handling.

Fourth. To automatically keep a record of the total quantities delivered, thus enabling the storekeeper to have an accurate check of oils used during a given period.

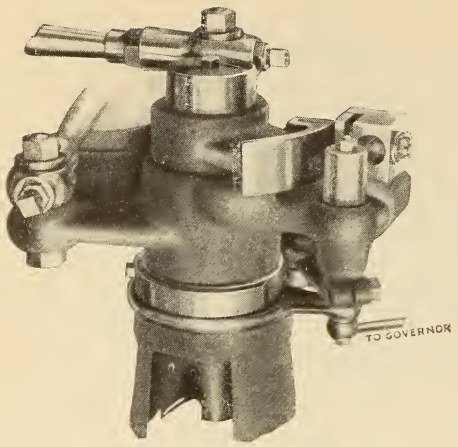
Fifth. To provide a means whereby the oil storage may be readily replenished without interfering with the operation of the system.

The first floor of this oil house will be used in addition to the disbursement of oil for the storage and care of the individual kits of the engineers.

For the comfort and welfare of the enginemen and firemen going into this terminal, a restaurant, wash and locker room have been provided, together with shower baths, reading-room, bunk room, etc., in the roundhouse office building or rest house. This building will also take care of the roundhouse foremen, engine dispatchers, clerks, etc., and will be the central for a complete system of intercommunicating telephones for the entire shops.

The switchboard is the Western Electric Company's No. 1,260, similar to the board shown in the accompanying illustration, and embodies the results of thirty-five years' experience in the manufacture of telephone apparatus and switchboards and the latest developments in the telephone art. It is a non-multiple, single position, lamp signal, central battery type operating from a 22-volt storage battery. Its present equipment is for thirty extension lines or stations, with five-cord or connecting circuits and one trunk line to central office, while the capacity of the switchboard is sixty extension lines, ten-cord circuits and five trunks to magneto central office. The extension stations are of the desk telephone type.

The power plant, which is an "L"-shaped building, 156 x 121 feet, with boiler room 41 feet wide and



LATCH GEAR OF THE COOPER CORLISS ENGINE

engine and pump room 80 feet wide, is only auxiliary, inasmuch as the power for the plant will be furnished by the Mechanicsville power station of the Delaware & Hudson Company, about 20 miles north of the shops. Power will be delivered at 11,000 volts, 40 cycles, and transformed to 240 volts A. C., a motor-generator set being provided for the conversion of this power into D. C. at 240 volts. As a protection, the power plant is provided with a 350-kilowatt, D. C. reciprocating steam unit, the engine for which is of the Corliss type, high-pressure cylinder, 18-inch bore, 30-inch stroke, built by the C. & G. Cooper Company, Mount Vernon, Ohio. It is direct connected with a 350-kilowatt direct-current generator, and runs 150 r. p. m.

This engine is of the most modern heavy-duty design for use in direct-connected electrical service, the higher rotative speed being made possible by the use of the improved Cooper gravity latch valve gear, which is particularly adapted for higher operating speeds, the essential feature being that the latching or hooking-up operation is performed by a pick-up plunger through the action of gravity.

An operating feature of special importance and distinctive to this gear only is that the working faces of the steel block edges are maintained in the same parallel line under all operating conditions, thus wearing the block faces evenly instead of rounding them off, as in all other types.

This gear has the advantages of being noiseless, simple and easily accessible. The use of double-ported steam and exhaust valves in the cylinders, thereby reducing the valve travels to a minimum, adds to the ease of operation at the higher speeds, and the generator furnished by the General Electric Company will be able to work back through the motor generator set and deliver sufficient alternating current for the lighting of the shops in the event of any transmission trouble, due to lighting, etc., in the main source of supply from Mechanicsville.

The power plant is also equipped with a very generous compressed air supply system of 2,000 feet per minute capacity steam air compressor and a 2,000 feet capacity per minute motor-driven air compressor, both of which machines were furnished by the Ingersoll-Rand Company.

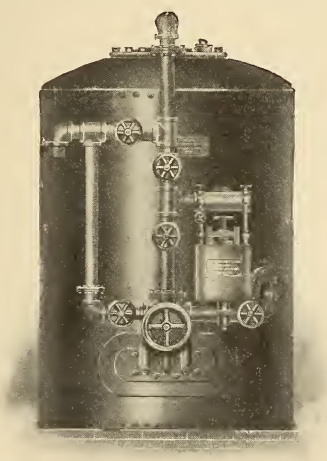
The steam power is generated by a boiler equipment of six Babcock & Wilcox wrought-steel boilers, set in three batteries; each boiler consists of sixteen sections, twelve tubes high, and is rated at 400 horsepower. The three batteries are connected by a flue in the rear to a stack 9 feet 6 inches in diameter by approximately 208 feet high. The furnaces are Webster patented furnaces, equipped with shaking grates for the burning of bird's-eye coal, for the purpose of combustion of which forced draft is provided through the medium of two 8-foot fans.

These fans, which were built by the Green Fuel Economizer Company, of Matteawan, N. .Y., are placed alongside of the boilers and discharge at the bottom into horizontal concrete air ducts passing underneath the boilers. The normal capacity of each fan is 40,000 cubic feet of air per minute, but they are

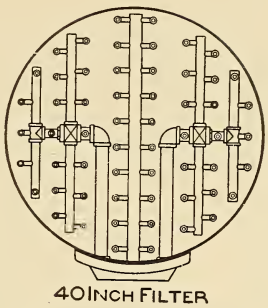
designed to supply 63,000 cubic feet of air per minute when run at a somewhat higher speed.

Although not necessary to the operation of the boilers with the forced draft, a 210-foot stack has been provided as a safeguard against boiler failures, due to trouble which may develop in the fans. This stack will give a fairly good draft, even for the burning of the low-grade fuel which will be used. This stack was built by the General Concrete Construction Company, of Chicago, Ill.

It was necessary to protect the plant by a system of water supply, and after a thorough test of the underlying strata by means of drills, it was found that a bed of gravel and sand approximately 20 feet thick, extended from the shops to the Hudson River, about half a mile away, and an open well was dug, 60 feet in diameter, to bed-rock, approximately 50 feet below the shop grade. This well was put down in the shape of an open ditch and concrete walls built in sections from the bed-rock, the sheet piping being pulled from the bottom. This sheet piping had to be carried from the top, owing to the loose gravel through which the well was sunk. After the core wall had been completed and the ditch back filled on the outside, the core remaining was taken out. Two 1,000-gallon-per-minute centrifugal pumps were installed, being operated by 60-horse-power motors, which motors are automatically stopped and started, as required, operating switches being provided.



SECTIONAL WASH VERTICAL PRESSURE FILTER, JEWELL SYSTEM

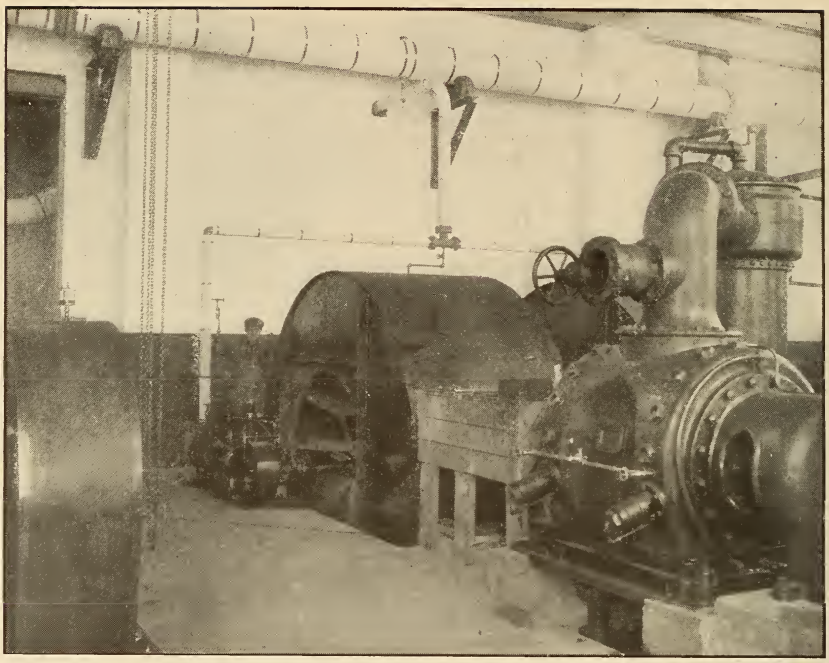


PLAN OF STRAINER SYSTEM

These pumps deliver into a 10-inch main leading into a tank 30 feet in diameter and 60 feet high, having a capacity of 317,280 gallons. This tank, which is built on masonry foundations and is without roof, was constructed by the Des Moines Bridge & Iron Company, of Des Moines, Ia., from plans and specifications furnished by the Delaware & Hudson Company, and a 100,000-gallon tank, the bottom of which is at the same elevation as the delivery line in the large tank. Approximately 200,000 gallons of water are available at all times for fire protection, for which purpose fire pumps have been installed. The entire plant has been protected by sprinklers, for which use a 50,000-gallon tank has been installed.

The water obtained from the well, although at the present time free from organic matter, will be filtered for drinking purposes.

The water filter which is installed in the power house is known as the "Improved New York Sectional Wash Vertical Pressure Filter," built by the New York Continental Jewell Filtration Company, of New York, and the supply will be pumped



VIEW IN POWER HOUSE, DELAWARE & HUDSON COMPANY, SHOWING FAN BUILT BY GREEN FUEL ECONOMIZER COMPANY

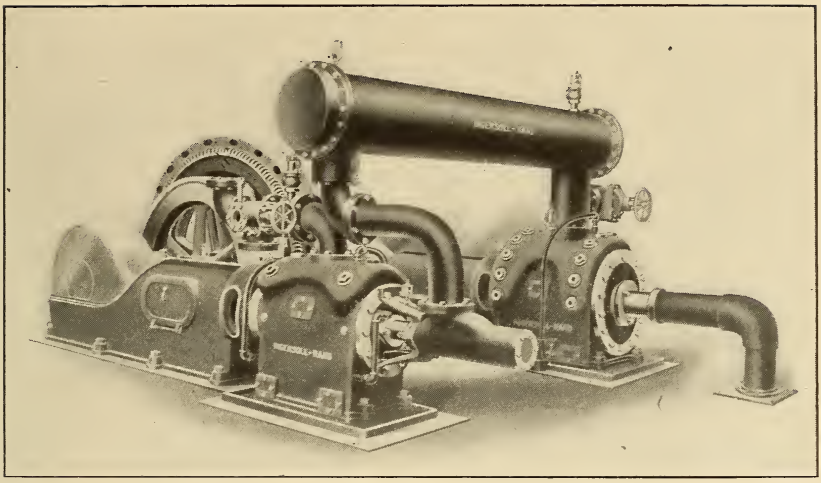
from the filter to a 10,000-gallon tank.

This filter, which is illustrated here, has an inside diameter of 40 inches and stands 5 feet 6 inches high.

It is supplied by a 2-inch line, and when operating at the slow rate of filtration required to obtain the high bacteriological efficiency demanded by the State Board of Health on municipal filtration plants, has a minimum capacity of 20 gallons per minute. For general purposes, however, unless the unfiltered water is very turbid, water may be drawn through the filter at a rate, perhaps, 50 per cent. in excess of the capacity designated, with satisfactory results.

The filtering material consists of several grades of pebbles and screened silica sand, the coarse material being in the bottom of the tank. The water, in filtering, enters the filter at the top and percolates down through the bed and out through the strainer system of the filter, shown in the plan view. This strainer system consists of the latest Jewell strainers, which are pear-shaped, and of cast bronze, the upper portion being pierced with twenty-four saw slots, each one-fiftieth of an inch in diameter, these apertures being smaller than the smallest grain of sand in the filter bed. The filters are screwed into wrought-iron lateral pipes, and the entire strainer system is embedded in concrete in the base of the filter, leaving only the top portion of the strainers with the apertures exposed.

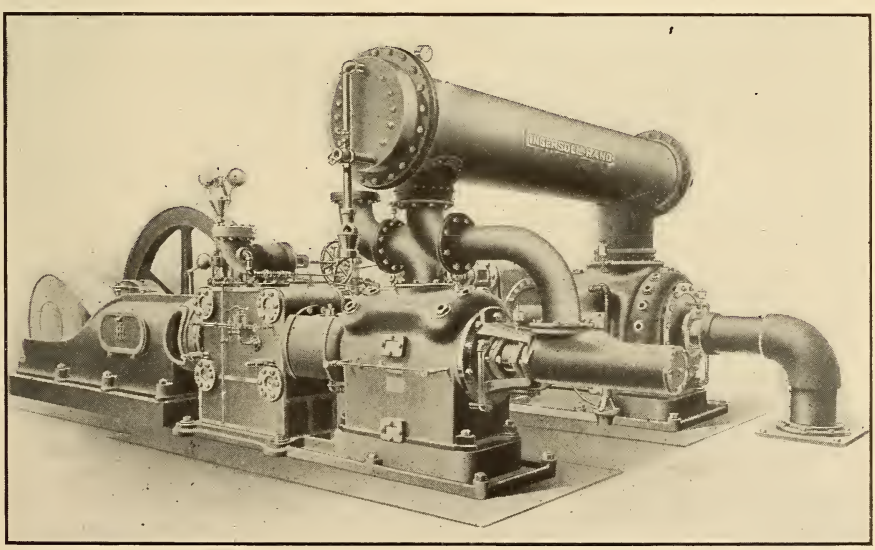
All filters are alike to the extent that they are cleaned or "washed" by reversing the current of water through the bed of filtering material in the direction opposite to which it flows when filtering, thus washing the collected impurities into the sewer; but the "sectional wash" arrangement of the strainer system differs from others, in that by means of the controlling valve, into which the three sections of the strainers converge, the entire full volume of the reverse flow is concentrated into



INGERSOLL-RAND AIR COMPRESSOR AT THE WATERVLIET SHOPS

each of the sections in turn. This gives to each section of the bed the increased volume and velocity required for a quick and economical wash, and takes the place of rakes, the so-called "air wash," special washing pumps, and other extraneous devices. By this method the filter can be thoroughly cleaned in ten minutes or less.

The raw water on its passage into the filter picks up a small quantity of alum by means of the automatic coagulating device, consisting of back pressure valve and cast-iron alum tank, shown on the front of the filter. By means of this arrangement the operator of the filter has absolute control of the varying conditions of the raw water. This chemically induced coagulation is the real essence of mechanical filtration, and is the chief reason why, in a mechanical filter, the same result can be obtained by a rate of flow forty to sixty times as high as could be



INGERSOLL-RAND AIR COMPRESSOR, WITH INGERSOLL-RAND CORLISS STEAM CYLINDERS

employed in the old-fashioned English slow sand filter, which was man's first attempt at imitating Nature in the purification of water. The alum combines with the carbonates in the raw water to form hydrate of alumina, which is a sticky, gelatinous-like mass. This is deposited on the top of the filter bed and catches the finely divided clay particles and disease germs, which are so small as to be invisible to the naked eye, and would, therefore, slip through the interstices between the grains of sand.

In connection with the coach cleaning and classification yard complete systems of compressed air, hot and cold water and vacuum cleaning systems have been installed. This coach cleaning and classification yard, as will be noted from the drawing, is of very large capacity. This is brought about by the extremely heavy summer business of the Delaware & Hudson Company to their Adirondack resorts. This coach cleaning and classification yard is provided with a one-story and basement supply building, 96 x 19 feet, in which will be located the Pullman supplies, coach supplies, etc., toilet facilities for the coach yard and freight car shop employees, etc.

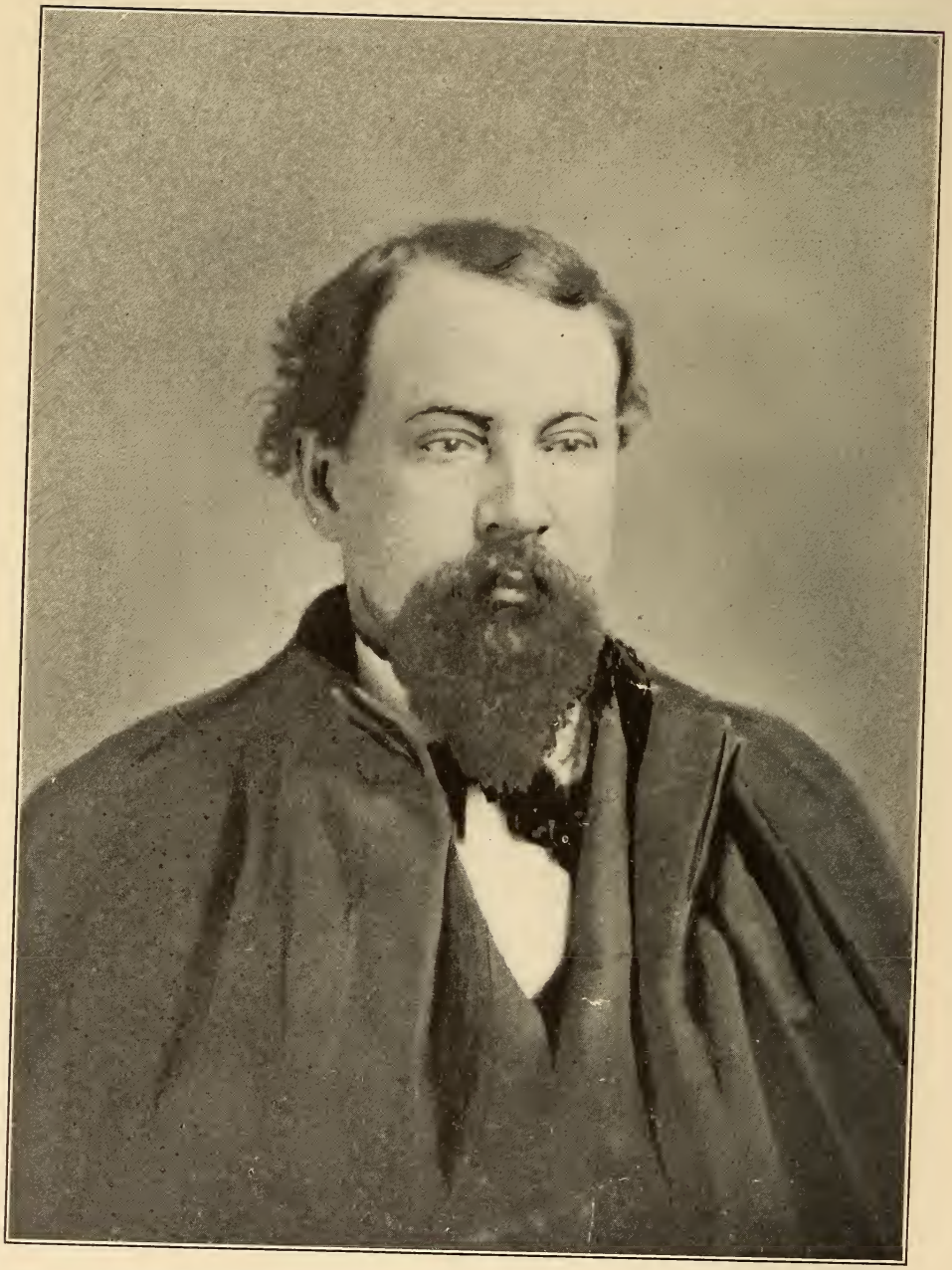
The shops will also take care of freight car repair work incident to this end of the line by means of a freight car repair shop, cross-section of which is given. The building is 268 x 104 feet, and is served by two 15-ton cranes. Between every alternative bay, both inside and outside of the building, will be standard gauge lorry tracks for the economical handling of material, which track system will connect with the planing mill, which is 180 x 68 feet, and the truck shop and sub-storehouse, which is 92 x 68 feet. The planing mill is served by a yard crane runway, 450 feet long and 85 feet wide, for handling heavy dimensioned timber.

Tying the entire plant together is a cross crane runway, 1,162 feet long, 67 feet 6 inches span, furnished with a 5-ton capacity high-speed crane. The crane and track service will make it possible to handle material from any part of the plant without manual labour.

As will be seen from this description, this new and most extensive plant is an up-to-date one in all respects, and has been carefully planned and constructed in accordance with the best ideals of modern practice, with a view of giving the highest possible efficiency in its many departments of industrial work. Both the Delaware & Hudson Company and their consulting engineer, Mr. V. Z. Caracristi, are to be congratulated on the successful completion of this vast and important enterprise.

George B. Brayton, pioneer in the development of the internal-combustion engine, and a most brilliant mechanic and investigator, was born at Compton, Rhode Island, in 1830. He received his education at a school in a village called Pond Factory, and early showed an inclination toward mechanics, making a little water-wheel and hammer at the early age of 4½ years. His father was the superintendent of a cotton factory, and invented several attachments to looms, from the proceeds of which he purchased a farm near Warwick, R. I., where George made his first experiments upon combustion in a cylinder, using camphene as a fuel; this was in the year 1853. Brayton learned his trade as a machinist at "Tom Hill's" machine shop in Providence, and at the Corliss Engine Works. Among his early inventions were a breech-loading gun, and a riveting machine for tank and gasometer work. In 1848 he turned his attention to steam boiler design, and invented the sectional steam generator, called the Exeter boiler, extensively manufactured by the Exeter Machine Works, of Exeter, N. H.

The internal-combustion engine, by which Brayton's name is best remembered, was first developed by him at Bricksburg, N. J., about 1870, and began to attract attention by 1873, after tests and a report by Professor Thurston, and by exhibition before the Franklin Institute, and is remarkable in that it employed a cycle of controlled combustion similar to that since so widely developed by Diesel and others. The "Ready Motor," as it was called, used oil fuel directly in the cylinder without a carburetter, and had a separate compression pump for the air supply, and worked steadily and more efficiently than any combustion engine produced to that time. In 1878 its construction was undertaken in England by Messrs. Simon, of Nottingham. After the introduction of gas engines of the Beau-de-Rochas type, the Brayton engine fell into disuse, but it is now realized that the machine was a most important and original invention, and that the principle upon which it was designed is the one governing the modern successful oil engine of maximum efficiency. Brayton died at Kingsbury, England, December 17, 1892, and his remains were interred at Providence, R. I., January 24, 1893.



GEORGE B. BRAYTON

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INCREASING HUMAN EFFICIENCY BY OZONE

By W. H. Radcliffe

AMONG the factors that lower human efficiency in its general sense some of the most important are the bodily ailments brought on by breathing foul indoor air. Tuberculosis, pneumonia, grippe, asthma, catarrh, bronchitis, tonsilitis and pulmonary affections of all kinds are directly traceable to breathing indoor air laden with decaying organic matter, which forms the home and conveyance of disease microbes.

The decomposition continually going on upon the surface of our bodies, as well as in our noses, mouths and throats, is one of the principal sources of this decaying organic matter or "air sewage," which is readily thrown off into the air by the natural movements of the body.

In factories, shops, offices, schools and similar places where many persons are confined in a limited space, the "air sewage" is more dense and the results more deadly than elsewhere. The fact that it is invisible, and often imperceptible to the sense of smell, renders the danger all the more serious. In all places, but especially where human efficiency and endurance count for most, it is, therefore, important that every practical means be taken to free the air from depressing and poisonous effects of this nature.

To accomplish this, window ventilation is the simplest and cheapest method, but has its drawbacks and its serious dangers. While it is true that anyone can ventilate a room by opening windows, and by the use of properly designed window ventilators can induce a circulation of air without producing injurious drafts, it is also true that outside air, when warmed to a comfortable temperature in winter weather, does not possess the same bracing, invigorating effect that comes from breathing fresh outdoor air. For this same reason a consumptive does not obtain the same beneficial results by drawing the head of his bed close to a wide-open window as he does from sleeping in the open.

The fact that outside air in many places, and particularly in cities, is not as good as it should be still further complicates the problem. Escaping sewer gases, smoke, dirt and the exhalations from the lungs and bodies of men and animals, all tend to vitiate the outside air. Every city man who takes even a day's outing in the country and has drawn into his lungs the fresh, crisp air of the mountains, the seashore or the farm, knows the difference between city and country air. Everyone knows how lightning in a thunder-

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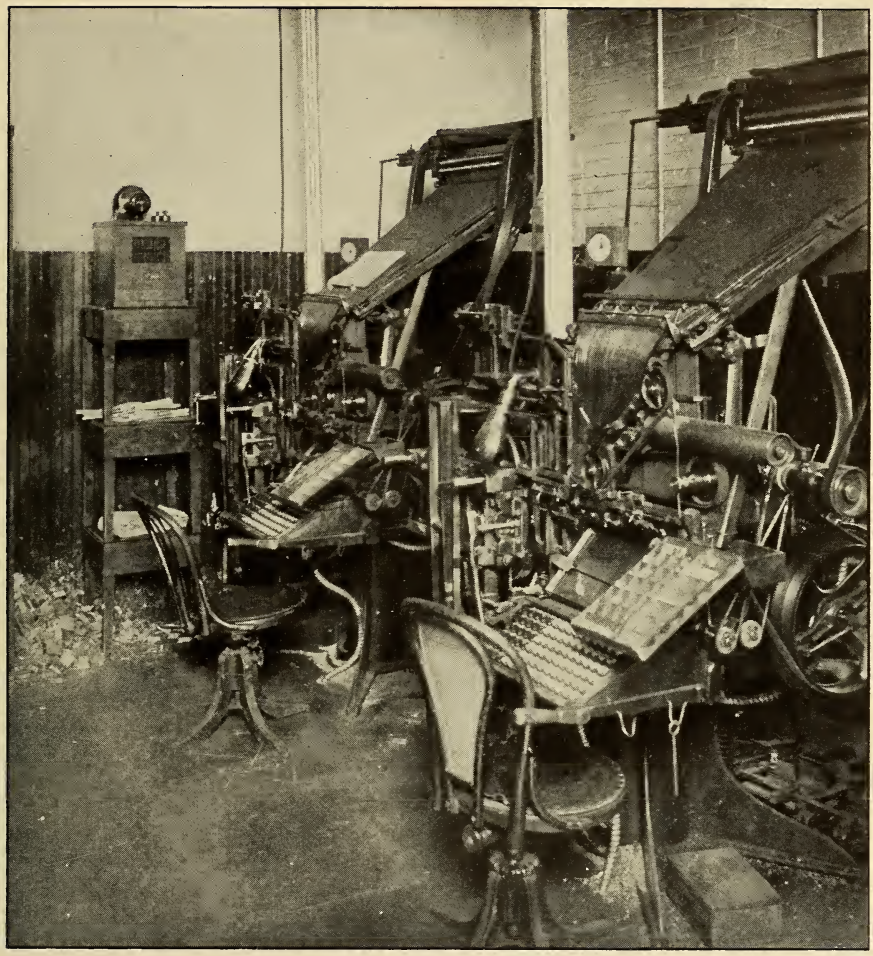
storm clears the atmosphere and makes it more exhilarating—how one is apt to thump himself on the chest at such times and exclaim: "Just smell the ozone!"

Ozone, in reality, is the answer to the pure air problem; it is the missing link between pure air and foul air, between health and illness, between human efficiency and dullness of mind and body.

But how few, even among those who have experienced the stimulating effects of ozone, know what it really is and how it is formed.

Until recently there was little opportunity of becoming acquainted with the nature and development of ozone for indoor purification, because only Nature produced it in sufficient quantities to purify the air. Nature generates ozone by the ultra violet rays of either sunlight or electricity acting upon the oxygen of the air. Although temporarily noticeable whenever thunderstorms occur, it is

OZONATOR IN THE SCHENECTADY TRUST COMPANY, SCHENECTADY, N. Y.



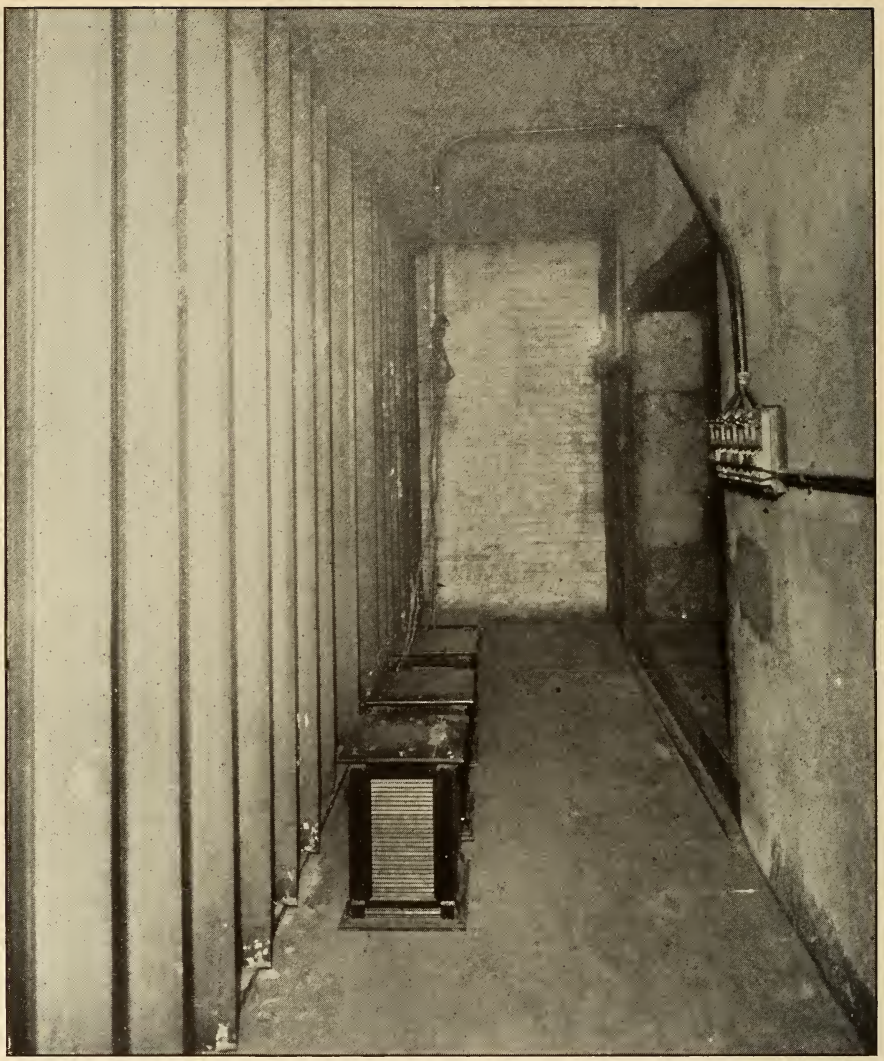
FOUL AIR IN THE COMPOSING ROOM OF THE SCHENECTADY GAZETTE WAS OVERCOME BY THE OZONE INSTALLATION, SHOWN IN THE BACKGROUND

found more abundantly in the lighter air strata and near large bodies of water and forests, especially near forests composed of pine trees.

Within the past few years, ozone machines for indoor use have been devised and placed on the market whereby this gas can be artificially made for combining with the "air sewage" previously mentioned and forming harmless products. In view of the increasing use of these ozonizers in business and home life, one should be informed about the qualities of ozone and how it is made.

Ozone is a particularly active or concentrated form of oxygen. One molecule of oxygen contains two atoms; a molecule of ozone contains three atoms. As only two atoms of oxygen balance harmoniously in a molecule, when there are three of them together in a molecule the third atom will cut loose and seek a union elsewhere. The oxygen atom has a remarkable affinity for carbon, of which decaying organic matter is a common form, and as the greater part of organic matter in the air is in process of decay, the third atom at once attacks and oxidizes it, burning it up.

The effect of ozone upon decaying organic matter has been appropriately



BASEMENT OF THE NATIONAL PARK BANK, NEW YORK CITY

Four Ozone machines are placed in the intake air chamber and an exhaust fan draws up the ozonized air through an airshaft into the bank. New York Edison Company.

likened to that of fire on deadwood, lime on sewage, or peroxide of hydrogen upon a contaminated wound.

It is obvious that, with sufficient ozone in the air, there cannot be organic impurities present for any appreciable length of time. Extravagant claims, however, have been made that ozone kills microbes in the air. This is not the case when supplied in the commonly diluted form for continuous breathing.

Strong concentrations are objectionable because of the stringent odour of ozone imparted to the air and the irritation produced upon the respiratory organs, but are much used in hospitals to sterilize bandages, sheets, etc., and in refrigerating plants to help preserve fruits, meats, and the like. In the usually diluted form for indoor air purification (1 part ozone to 1,000,000 parts air) the odour of ozone somewhat re-

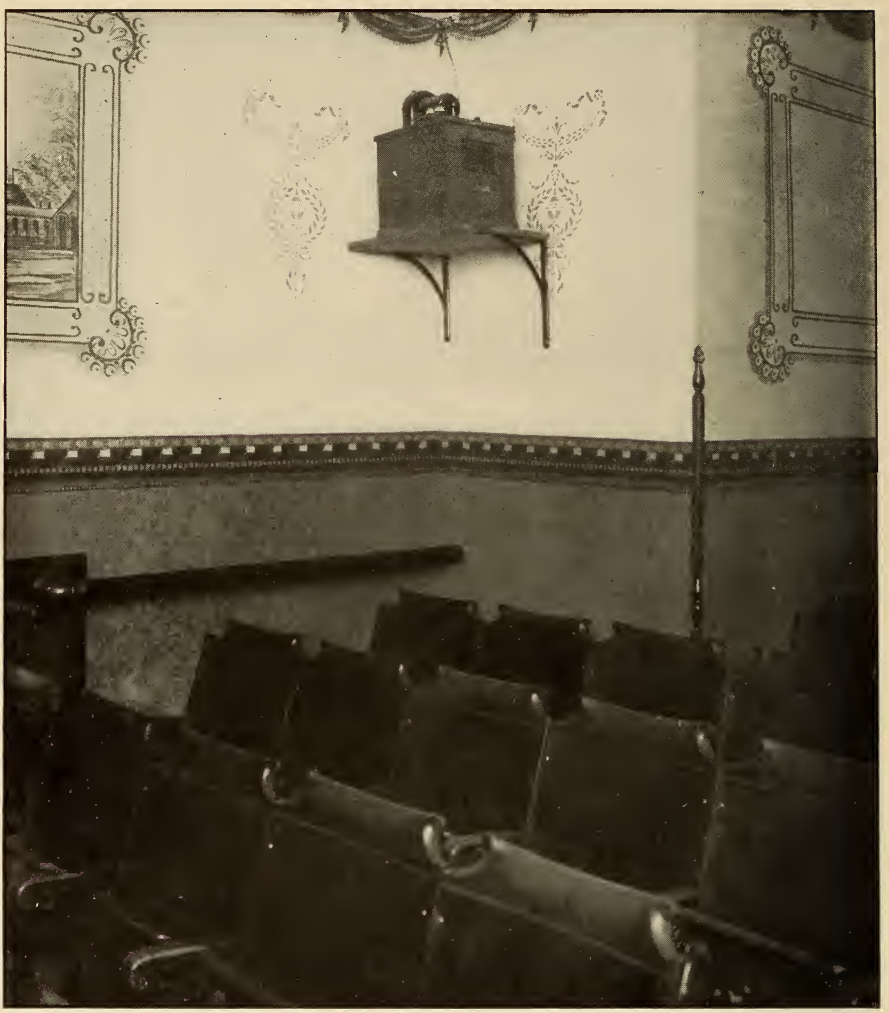
sembles that of freshly bleached linen; and while noticeable, is not at all unpleasant, and is absolutely harmless.

The machine used in generating ozone for ordinary indoor use in offices, schools, factories, stores and similar places occupies but little more space than an electric fan, and is comparatively inexpensive in maintenance. All that is necessary is to connect it to an ordinary electric-lamp socket in the same manner as an electric fan and turn it on and off, as required.

The lighting current is transformed by the machine into alternating current of high pressure, 8,000 to 50,000 volts, and this is silently discharged into the atmosphere by being made to jump across an air space from one metal plate to another. A violet colored glow accompanies the discharge, which, acting upon the oxygen of the air, breaks up every three oxygen molecules of two atoms each into two ozone molecules of three atoms each. These three-atom molecules form a condition that can exist only temporarily, the third atom breaking away to unite with and destroy organic matter.

Besides oxygen gas, there is present in the air, as we all know, nitro-

OZONE PLANT IN THE GALLERY OF THE NATIONAL PARK BANK, NEW YORK CITY, FOR PURIFYING THE AIR IN THE MAIN BANKING ROOM



THE ART THEATRE, SCHENECTADY, N. Y. THE PURE AIR PROBLEM SOLVED BY INSTALLING AN OZONE MACHINE ON THE WALL.

gen gas in much larger quantities. If the electrical discharge in an ozone generator is sufficiently intense it will not only convert the oxygen gas into ozone, but will act upon the nitrogen gas and form nitric acid. It is, therefore, necessary in the design of ozone generators to keep the electric intensity below that value at which the nitrogen gas is attacked. Disregard of this point in an effort to increase the production of ozone and to keep the dimensions of ozonizers small has rendered some commercial forms of these machines useless.

To afford the ozone molecules an opportunity to act to the best advantage upon the impurities in the air, their field of action is usually increased by the use of an ordinary electric fan mounted in the ozone machine, which blows out the ozone as it is formed, mixing it thoroughly with the air. A suitable wooden box encloses the fan and ozone generating apparatus so that they are entirely self-contained and there is no danger from electric shocks.

One type of machine delivers 10,000 cubic feet of ozonized air per

hour at a cost of less than half a cent, or one farthing, and there are larger machines that generate and discharge up to 20,000 cubic feet of ozonized air per hour, which, in turn, mildly ozonizes several times this volume of additional air. Small ozonizers without fan attachment are made for bedroom use.

In large buildings equipped with modern ventilating systems or with air ducts and shafts, ozone machines may be placed in the air ducts and the ozone diffused through the shaft to all parts of the building. An installation in the National Park Bank, New York City, is of this nature. Four large ozonizers are there placed in the intake chamber of the main supply fan. Air taken in through a screen behind the ozonizers is treated with ozone and then drawn up the air shaft and into the bank by means of an exhaust fan.

In addition to the four machines there are in this ozone plant four other large ones—three placed in bad air spots in the main banking room and one in the engine room, also three small ozonizers in the offices. Each of these machines is equipped with a 12-inch fan for the rapid diffusion of the ozone, and converters are used for changing the lighting current, which is direct, into alternating current for the ozonizers.

Another ozone plant of note is that of the New York *Tribune*, where the air in the city editors' office became so foul by reason of the large number of reporters and editors present that the ventilating system in use was discarded in favour of a portable ozone machine, and so great an improvement was noted in this office that the entire *Tribune* printing plant is now ozonized.

The Art Theatre, in Schenectady, N. Y., a moving-picture show, experienced difficulty with its ventilation. This is a hall about 30 by 100 feet, ventilation being provided by a suction blower capable of moving about 90,000 cubic feet of air per hour. It was found, however, that, notwithstanding the magnitude of the blower, "crowd odours" persisted in the room; but the blower was as large as could be used, for anything larger would have produced obnoxious drafts. As a solution of the trouble, an ozone machine was installed above the front entrance to the theatre in such a way as to permit the ozonized air to diffuse into the current of ventilating air drawn toward the uptake. The instantaneous effect of this was remarkable. The theatre has been entirely deodorized, and even during the hottest summer weather the air within the theatre is fresh, cool and odourless, excepting for the faint and rather pleasant smell of the slight excess of ozone.

Claims have been made that ozonized air promotes deep breathing, and thereby strengthens the lungs and increases the weight. For the purpose of testing the truth of these claims, the First National Bank of Chicago made an interesting experiment a short time ago on six employees who were working in one of the rooms of the auditor's department. Their individual weights and chest measurements were taken when an ozonizer was installed in the room and again at the end of two months, when it was found that every one of the men had gained in weight, as well as in chest measurement.

In London, the underground railways are soon to be freed of all disagreeable odours by forcing ozonized air through them at the rate of 900 cubic feet per passenger per hour. Throughout Europe, theatres, banks, restaurants and homes are supplied with ozonized air; and while America has been comparatively slow in recognizing the advantages of this invigorating and cleansing agent, the size and importance of the concerns that are now using it with such excellent results cannot but create an increasing demand for it.

HYDRAULIC POWER

II.—PARTICULAR APPLICATIONS.

By Joseph Horner

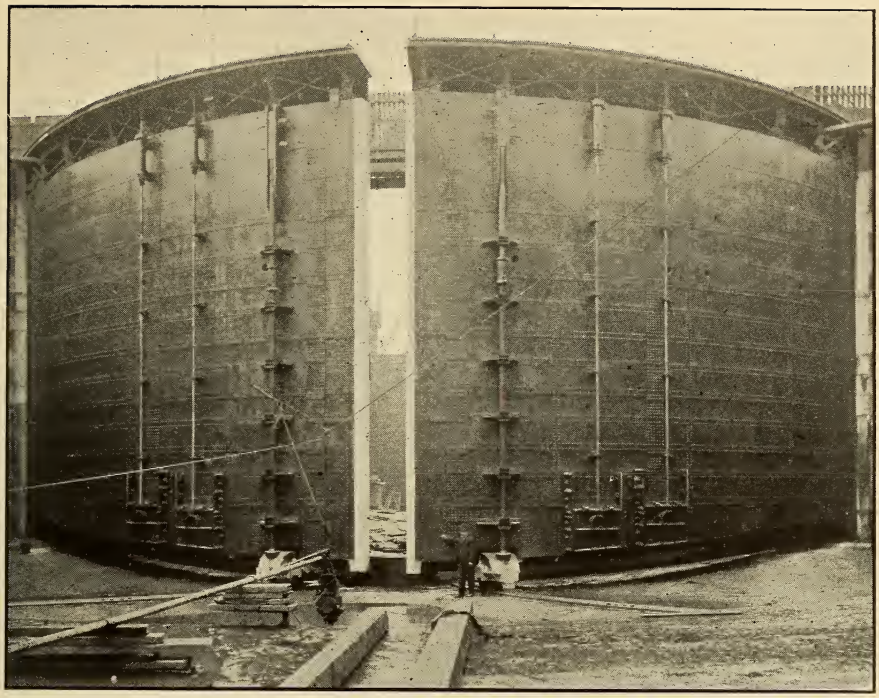
DOCK equipment has been instanced as a sphere in which the hydraulic machine is paramount. The gates are actuated by means of rams direct, or by means of chains. The latter are usually worked by hydraulic rams, or hydraulic engines; sometimes by steam or electricity. The direct-acting ram is by far the simpler method. If chains are used a system of drums or pulleys and sheaves has to be installed. In any hydraulic mechanism in which the action is not direct through the ram, chain transmission is necessary, as in many cranes and in dock gates. The least objectionable features are their mass and clumsiness, and wire rope cannot always be substituted, because the links and their cupped sheaves often affect the actual movements of precision. The principal objection is that they must be overhauled and annealed periodically, that they are liable to elongation or fracture by excessive stresses, and that duplicates must be kept. These are the reasons why direct-acting rams are frequently preferred. The entrance gates of the South Dock at Cardiff were until recently the largest built. Measured along the sill, each gate is 50 feet 6½ inches from centre of heel post to mitre post. Its height is 50½ feet. It runs on a roller path, and is opened and shut by direct-acting hydraulic rams fixed in masonry chambers built in the lock walls. The minimum pressure is 600 pounds per square inch. An illustration is given of gates actuated by direct-acting rams by Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Newcastle-on-Tyne.

The movements of bridges are mostly accomplished by hydraulic power, either applied by rams or water engines. These include bascule and swing bridges, many examples of which occur in England, America and on the Continent. Many of the swing bridges are supported on a hydraulic pivot, on which they are raised by the pressure of water, and turned. Pressure is applied by a pump through an accumulator, and the pressure to lift a mass of several hundreds of tons carried on a pivot of two feet or less in diameter has to be very high.

Never before have installations of lifts been so numerous. For these hydraulic power is used far more than electricity, both for heavy and light lifts. The direct-acting lift and the suspended lift divide favour. The direct is preferable for very heavy loads; for medium and light loads, the suspended and balanced systems, with safety devices.

There are some works which could not have been accomplished if hydraulic power had not provided the means for their operation. Notable among these are the Anderton and the Belgian canal lifts and the famous Barton aqueduct. The first two supply the place of ordinary locks, the last supplants a fixed aqueduct of masonry. Though well known, they may be cited as marvelous examples of the simplicity and utility of the hydraulic system.

The canal lifts, though few of them have been constructed, because the conditions which render them necessary or desirable are somewhat unique, will always command the admiration of engineers by reason of their boldness of conception and the



HYDRAULICALLY OPERATED DOCK GATES. W. G. ARMSTRONG, WHITWORTH & CO., LTD., NEWCASTLE-ON-TYNE

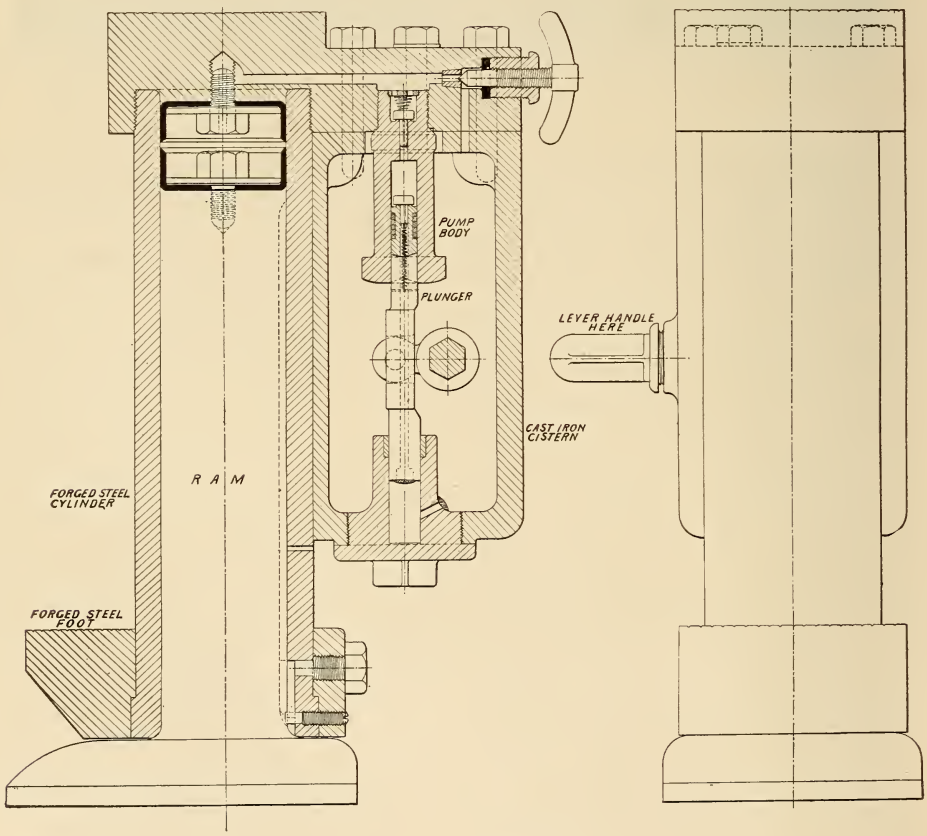
perfection of their mechanism. The Anderton canal lift of Sir Leader Williams showed the way; the others differed in some details, but not in essentials. The Anderton canal lift was designed to connect the River Weaver with the Trent and Mersey Canal at Anderton, to take the place of the locks hitherto used. The difference in level being 50 feet, the lift was accomplished by constructing an aqueduct of wrought iron, 162 feet 6 inches long and 34 feet 4 inches wide, divided into two channels, which, when filled with water 5 feet 3 inches deep, weighed 1,050 tons. The ends were closed by gates. Into or out of this aqueduct the barges were floated, being carried in troughs 75 feet long by 15 feet 6 inches wide, which troughs had gates similar to those in the aqueduct. The weight of each trough, loaded, was about 240 tons, each carried by a central ram of 3 feet diameter. The feature of interest is that one trough in descending could be made to lift the other by the abstraction of about 15 tons of water from the canal. On this system the lifts at Les Fontinettes and at La Louviere have been constructed. The latter joins two canals, which have a difference in height of 293 feet 6 inches in a distance of 9 1/3 miles, and which are connected by a series of lifts. If locks had been used, 40,000 tons of water would have had to be replaced daily. The canal lifts have a vertical movement of 50 feet 6 inches, and this is effected in two and one-half minutes by letting in about 60 tons of water, equal to a depth of 10 inches, into one trough. Extra power is supplied by two turbines, which pump 5,000 gallons per hour, chiefly to compensate for leakage and to lift the gates. Each trough, when loaded, weighs about 1,100 tons, and is lifted by a single ram 6 feet 6¾ inches in diameter.

The Barton canal aqueduct is a

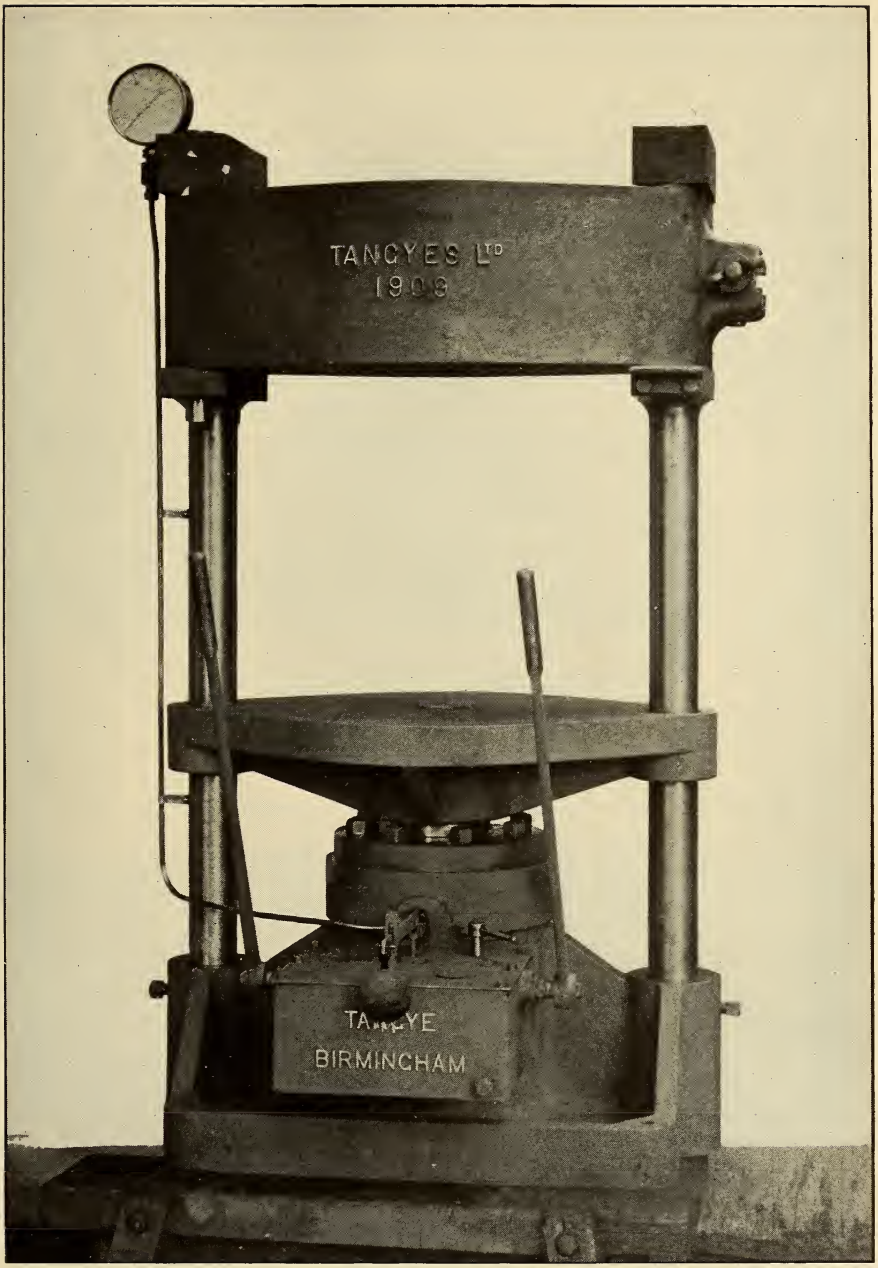
work of a different kind. Here the barges in the Bridgewater canal are carried over the Manchester Ship Canal by a swinging aqueduct pivoted on a pier at the centre, to leave a passage on each side when required. The aqueduct is always full of water, and the ends are closed with gates, opened only when the shore gates of the canal are opened to allow barges to go through. Its weight is 1,400 tons. The aqueduct is swung by hydraulic power on rollers between annular girders. But half the weight is taken by an hydraulic press, 4 feet 9½ inches in diameter, which forms the pivot.

The operation of tunnel boring shields is performed hydraulically. In later shields rams are disposed around the ring which forms the main body and are all coupled so that they are operated simultaneously by the pressure pumps. Pressure and return pipes are fitted, the return water being delivered back to the supply tank of the pumps, to be used again. The tunnel ring segments are sometimes lifted into place by another ram, the cylinder of which is pivoted to be turned into any required position. This is only adopted in large tunnels, where the segments are very heavy. If they do not exceed from 7 cwt. to 8 cwt., several men lift them.

Compressed air is a useful handmaid to hydraulic power in tunnel work, where the air is required for working under pressure and where hydraulic power is essential for thrusting the shield forward as the soil is excavated. Here, therefore, air-driven hydraulic pumps are used



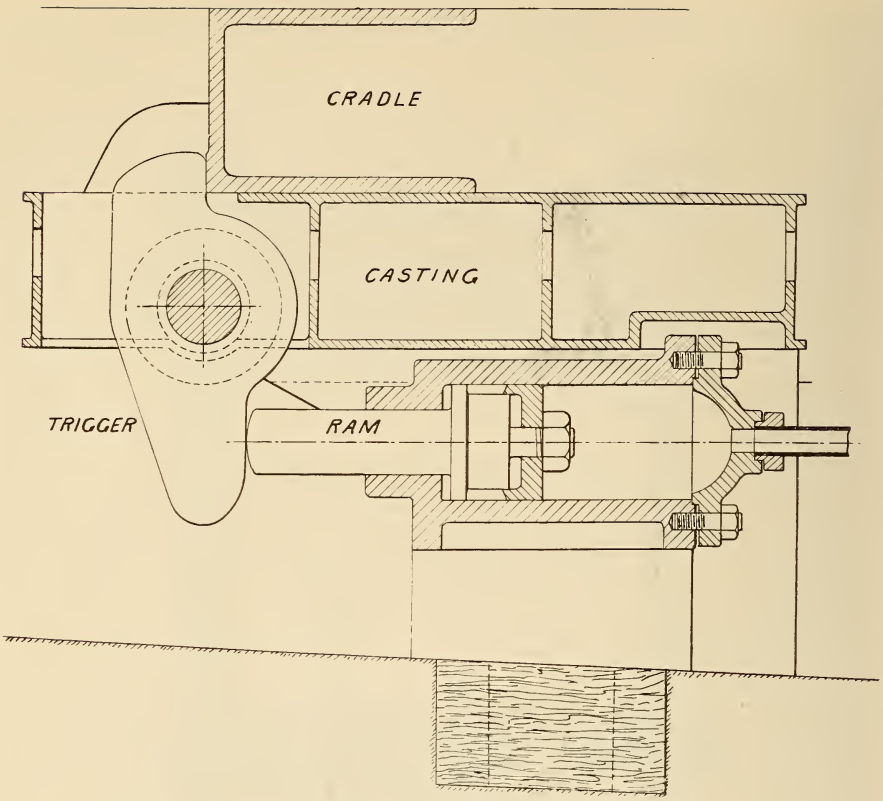
HYDRAULIC JACK. LOW TYPE WITH CISTERN AT THE SIDE. MESSRS. HOLT & WILLETTS, CRADLEY HEATH



HYDRAULIC 50-TON PRESS, SUPPLIED TO THE ELECTRIC DEPARTMENT OF DEVONPORT DOCKYARDS, FOR FORCING ON ARMATURE RINGS AND PRESSING COMMUTATORS. TANGYES, LTD., CORNWALL WORKS, BIRMINGHAM

The head is made in halves and provided with hinges and locking gear.

for supplying the pressure water to the rams. In the Central London Railway the pumps supplied by Messrs. Hayward, Tyler & Co. had 7-inch air cylinders and 1-inch water cylinders. A pressure of 50 pounds

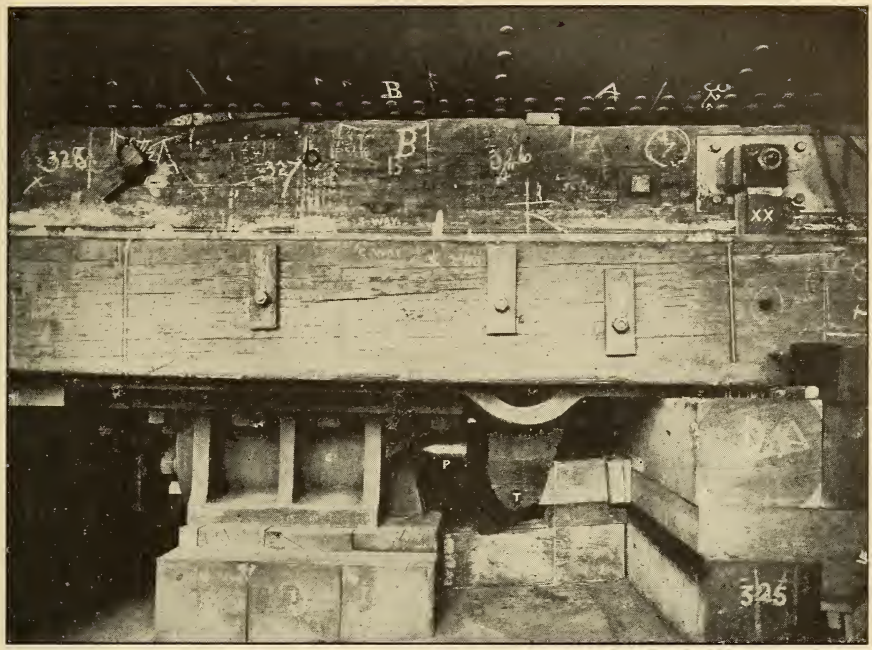


LAUNCHING TRIGGER, DESIGNED AND CONSTRUCTED BY HARLAND & WOLFF, LTD., BELFAST, IRELAND

per square inch of compressed air produced 1 ton per square inch of water. The water pressure used varied with the nature of the soil, ranging from 800 pounds to 1,600 pounds per square inch. The work is done much more quickly than when hand pumping is practiced.

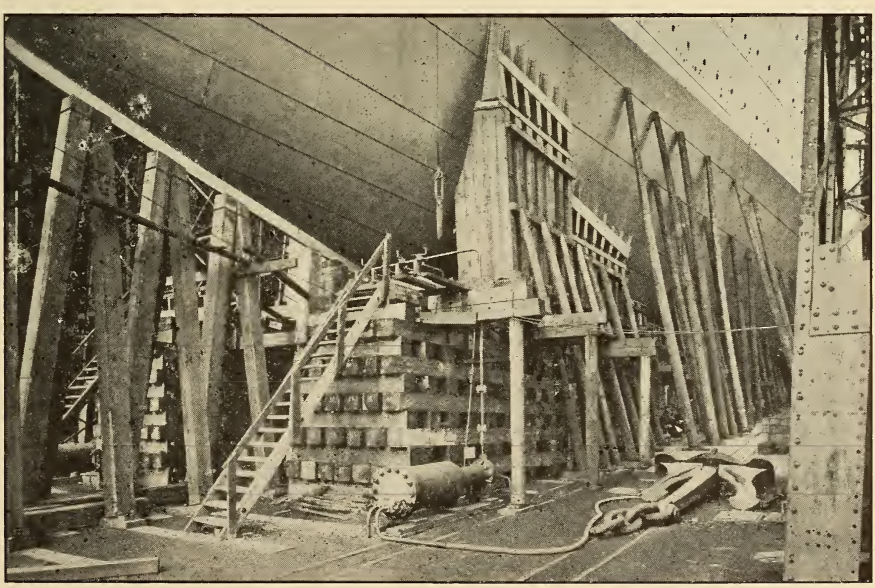
Jacks are made in many designs since James Tangye invented them. They lift on the head or on the foot; they pull or push; are fixed or traverse, and are suitable for loads up to as much as 400 tons. A mixture of glycerine and water, or alcohol and water, is used. A special type of jack is shown in the drawing, made by Messrs. Holt & Willets, of Cradley Heath, the feature in this being the position of the tank, which is located at the side. This reduces the total height of the jack, as compared with that design in which the tank is contained within the body. The foot is arranged to swing around to any angle, and can be locked by the set-screw; the full load may be lifted from the foot, as well as from the head.

Hydraulic rams and jacks are pressed into service in launching big ships. The old plan of knocking away wooden triggers is not suitable for the large vessels now built. The first time hydraulic jacks were used was on the *Great Eastern,* which laid the foundation of the great firm of the Tangyes, as told in "One and All." Illustrations are shown here of the launching arrangements of the *Olympic,* designed and constructed by Messrs. Harland & Wolff, Ltd., Shipbuilding and Engineering Works, Belfast. The trigger, of which there are two, one in each sliding way on each side of the ship, is of steel. Normally the upper part of the trigger—not seen in the photograph, but



LAUNCHING ARRANGEMENTS FOR THE S. S. OLYMPIC. HYDRAULIC RELEASING GEAR. HARLAND & WOLFF

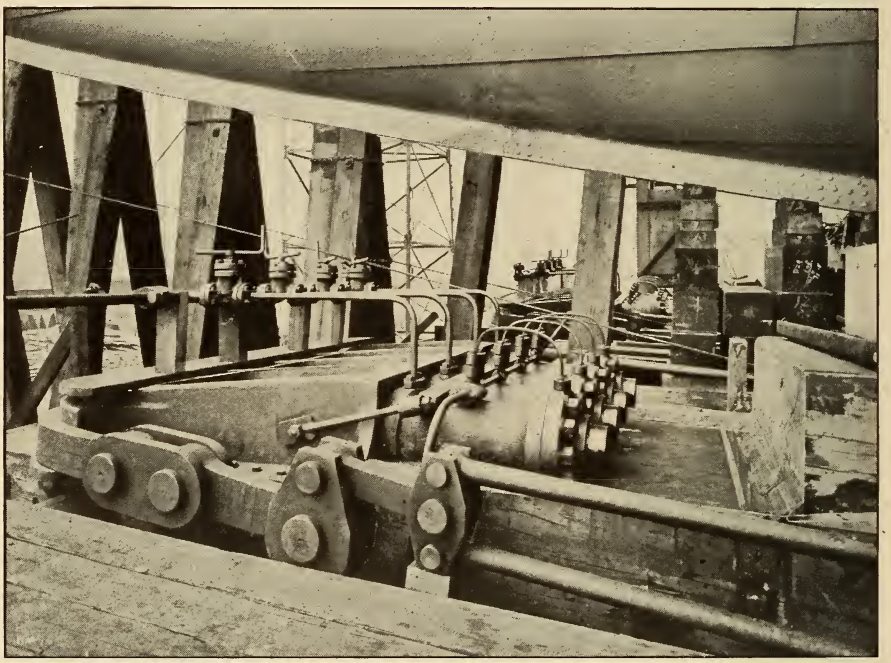
given in the drawing—pivoted on a fulcrum pin in a steel casting, is under pressure by the ship, which would move it but for the counter pressure of the hydraulic ram in the cylinder. But at the time of launching, after the dog shores have been removed, the opening of a valve



BOW CRADLE OF THE OLYMPIC, SHOWING 100-TON HYDRAULIC JACKS FOR GIVING IMPETUS. DESIGNED BY HARLAND & WOLFF, LTD.

releases the water in the hydraulic cylinder, the ram moves back, and the trigger falls over from the vertical into the horizontal position, leaving the vessel free to slide down the ways.

In the event of a hitch occurring, hydraulic jacks were rigged up as a standby, though they were not required. On each of the standing ways at the forward end, four 100-ton hydraulic jacks were fitted, the rams of which would act on the fore ends of the sliding ways through



HYDRAULIC LAUNCHING GEAR FOR THE S. S. OLYMPIC. HARLAND & WOLFF, LTD., BELFAST

heavy thrust distributing castings. Arrangements were made to receive the reaction of the jacks by means of a "strongback" and tension rods embedded in concrete with equalizing yokes. The jacks were to be worked by means of intensifiers, one of which is seen in the foreground. The jacks and their operating handles are shown in the illustrations. The jacks could be worked at a pressure of 2 tons per square inch.

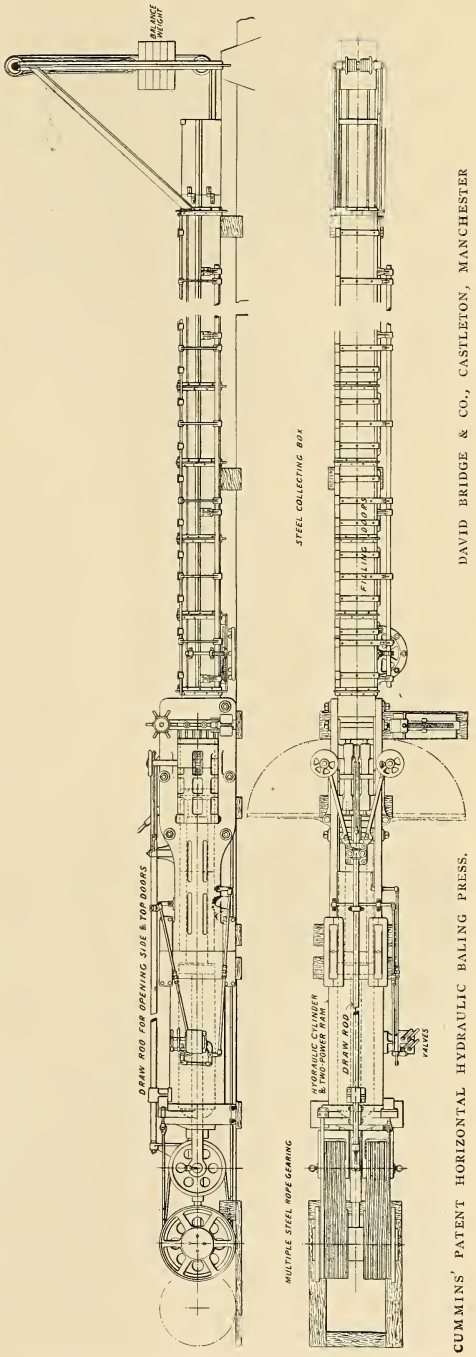
If the territory of the hydraulic engineers has been invaded in some directions, it has been extended and widened in others. New industries arise, new fields undreamed of open out, as happened when steel superseded iron, and when the practice of compressing goods for exportation and storage developed from the old screw-driven presses. Electricity both takes away and gives. It actuates some hydraulic pumps. It demands lead-coated electric cables, and the hydraulic press is required for this work. Rubber for electrical purposes and motor vehicles is boomed, and the presses are wanted here also.

So much work is now done in compressing and baling goods for export trade that the hydraulic presses here have a large exclusive and ever-extending field. Almost every machine is modified in its details to suit the particular kind of stuff pressed. But they are nearly all simple ram machines, actuated directly with pressure pumps without accumulators. These presses alone would afford an

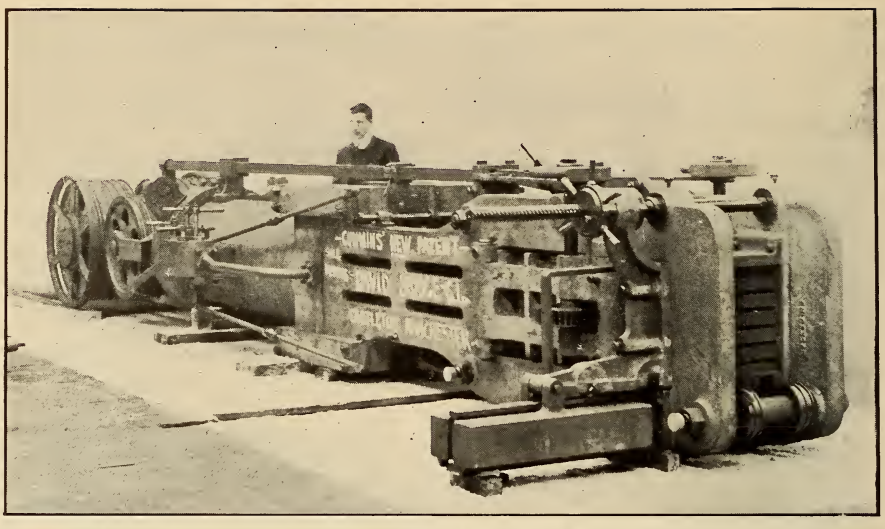
interesting study in adaptability and specialization. They are used for cotton, wool, hay, hops, esparto bark, hides, dry fodder, scrap iron for the baling furnace, etc. The whole of this work is appropriated by hydraulic engineers. It is one of those spheres in which pressure water is an ideal agent. Presses are mostly vertical, a fact which limits their range of movement. Foundations also have to be strong and secure. A rather remarkable development has been made in the horizontal baling press (Cummins' patent) manufactured by Messrs. David Bridge & Co., Ltd., of Castleton, Manchester. The press is shown broken off in the diagram to illustrate the mechanism. Essentially it comprises the squeezing ram, with multiplying ropes at one end and the balance weights at the other, by which the "follower" is brought back after squeezing, and the central and longer portion occupied by the steel collecting box into which the loose cotton, jute, hemp, china grass, coir, or other fibrous material is thrown.

The machine illustrated by the drawing measures 100 feet over all. The box is so long, containing a hundred square feet of space, that half a dozen unskilled coolies can be filling it at one time, quite loosely, in ten seconds, while one pressman can make from fifty to seventy 400-pound bales per hour, depending on the character of the material. The action is otherwise automatic. The action and method of working are as follows:

The box being filled with the loose material and the top loose doors closed, the backward stroke of the ram draws the material from it into the baling chamber, being thrust along by a follower in connection with the multiple rope gearing. The water-power used is small, being in proportion to the light duty, the ram being of the differential type. The small ram is used during the drawing in of the material and the preliminary compression of the bale. On the re-

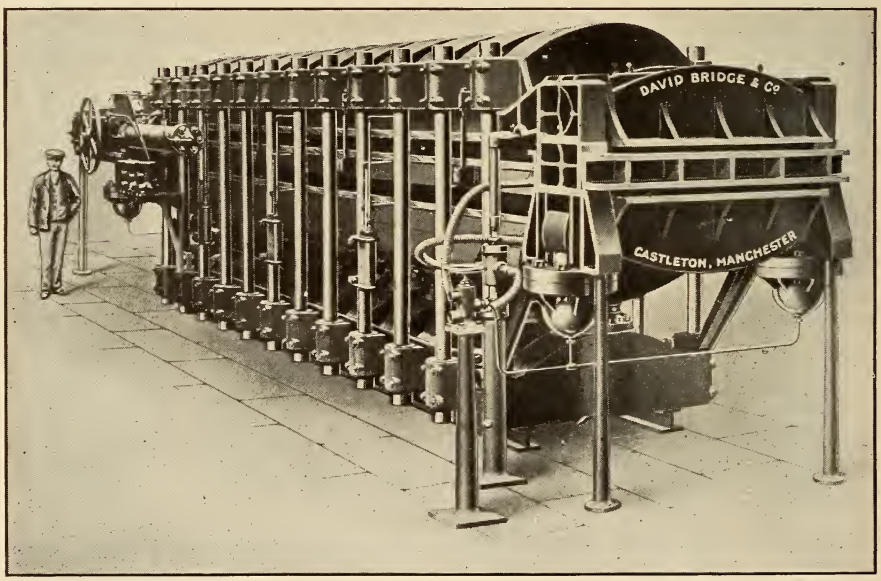


CUMMINS' PATENT HORIZONTAL HYDRAULIC BALING PRESS. DAVID BRIDGE & CO., CASTLETON, MANCHESTER

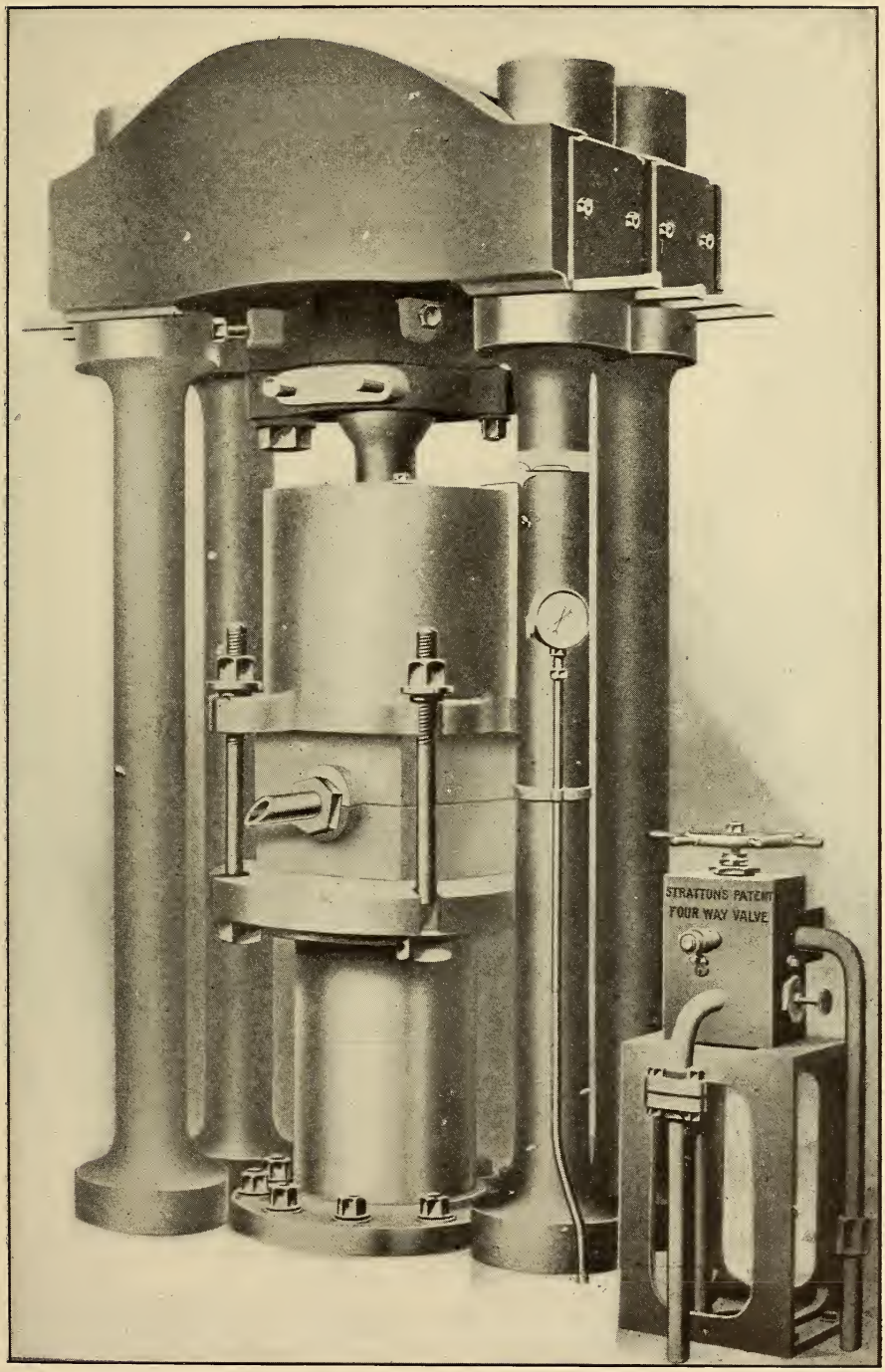


CUMMINS' HORIZONTAL BALING PRESS, SHOWING THE PRESSING END ONLY, WITHOUT THE FILLING BOXES. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

turn stroke the full power is put on only during the last few inches of pressure. On each stroke the ram is doing work, so that there is no lost stroke. Between the reversal of the movement of the ram a grid is inserted, then the ram is run to the right, still on the quick movement, until the lashing doors open automatically. Then the bale is pushed with the full power of the ram, lashed, and turned out of the press. The follower has now returned back to its limit, pulled back by the balance weights, and the loose material box has been filled in readiness for the next bale. All the movements except the box filling are automatic,



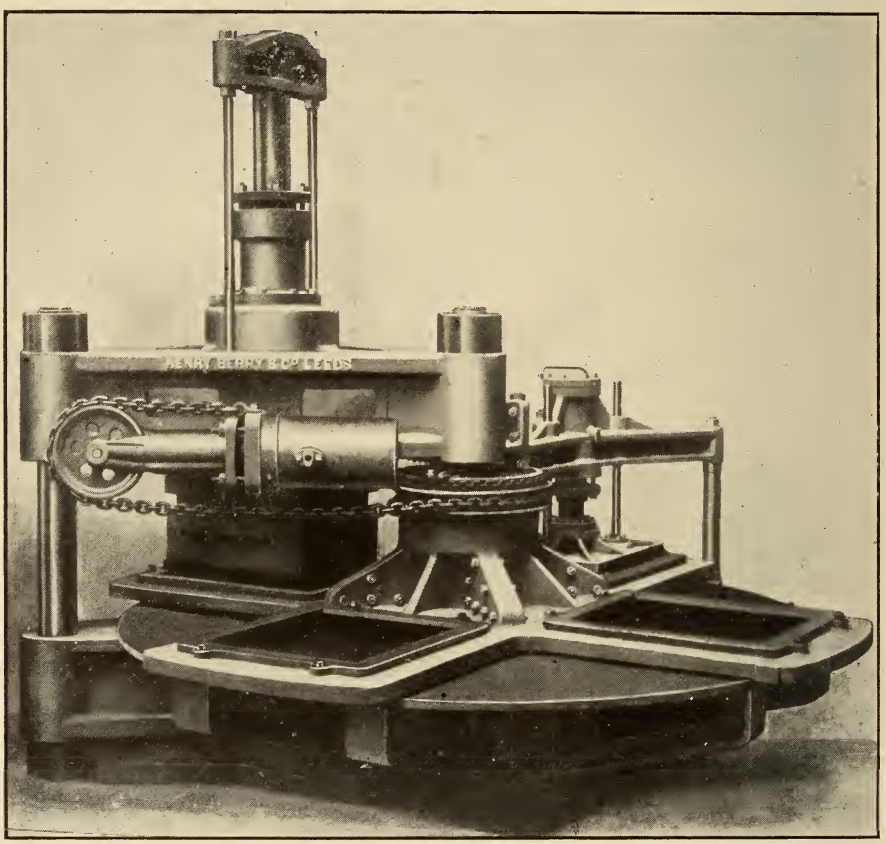
HYDRAULIC RUBBER BELTING AND SHEETING PRESS, 25 FT. LONG BY 50 IN. WIDE, WITH THREE STEAM-HEATED PLATENS. PROBABLY THE LARGEST PRESS IN EUROPE. DAVID BRIDGE & CO., LTD.



HYDRAULIC LEAD PRESS FOR COVERING CABLES WITH A SHEETING OF LEAD AND FOR MAKING LEAD PIPING. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

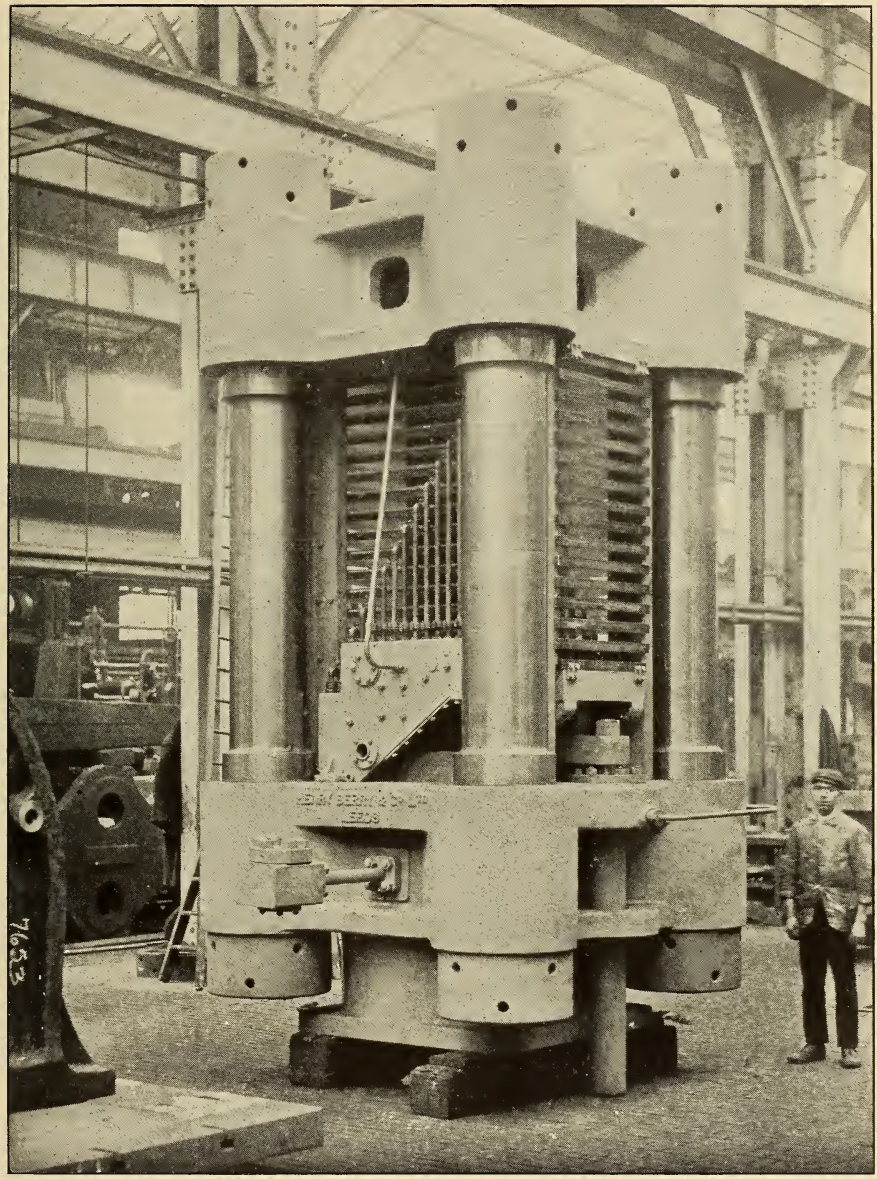
and all pipes, valves, etc., are above ground. No foundations are necessary, the weight of the press maintaining it in position. Wooden platforms, not shown, are ranged alongside the cotton box.

Another new industry is the making of artificial paving flags for footways in streets and the floors of buildings. Slag is used, or Portland cement and crushed stone. The concrete is placed in rectangular moulds and subjected to great pressure. A machine for this work, which reminds one of the turret principle, is built by Messrs. Henry Berry & Co., Ltd., of Leeds. A heavy revolving table in the form of a cross carries four holes, to which moulds are bolted. Work commences at the mould at the right of the illustration. A loose, but close-fitting, true metal plate is laid in the mould and rests on the fixed circular table below. The mould is then filled with concrete, and by means of chain gearing a quarter-turn is given to the revolving upper table, bringing the filled mould to the front of the illustration, where the concrete is leveled. Another quarter-turn brings it to the third position under the vertical ram, which, commencing its descent under a pressure of 500 pounds, is intensified to about 3,500 pounds per square inch. It is capable of exerting a total pressure of 500 tons. A final quarter-turn brings the flag to the



HYDRAULIC PRESS OF REVOLVING FOUR-MOULD TYPE, FOR MAKING ARTIFICIAL PAVING FLAGS. HENRY BERRY & CO., LTD., CROYDON WORKS, LEEDS

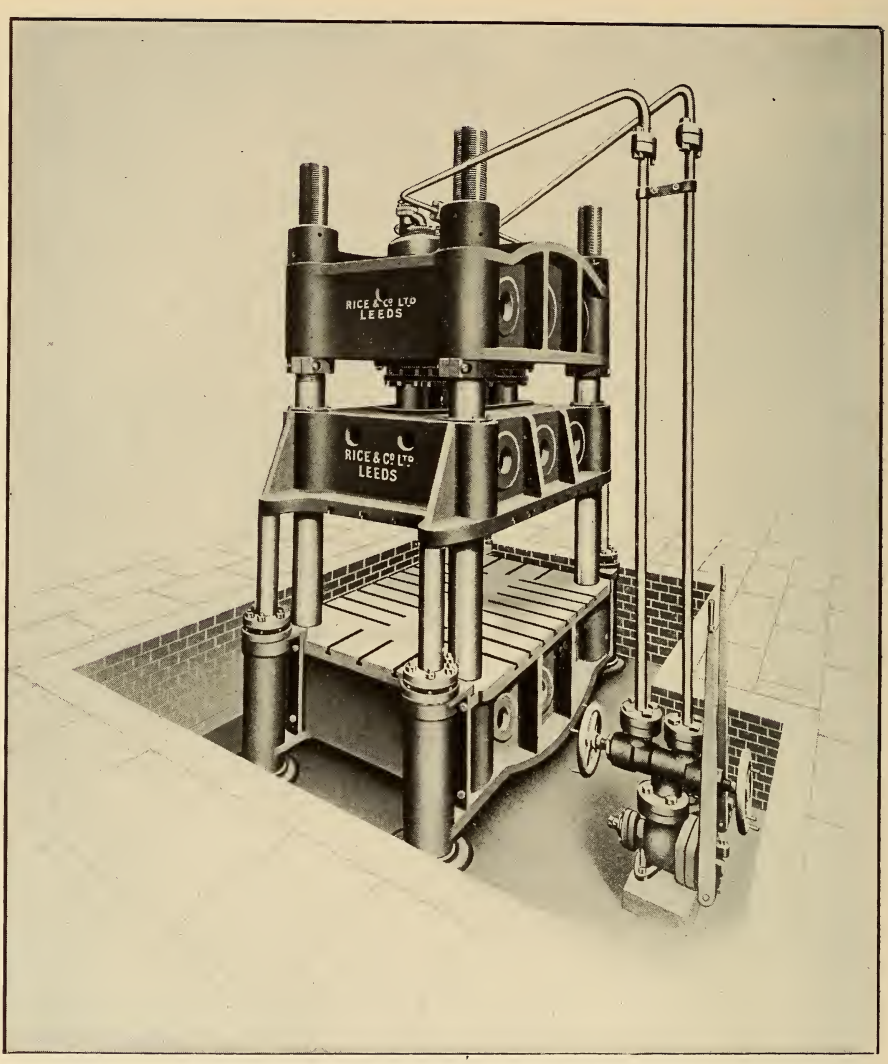
Each flag is subjected to a pressure of 500 tons. The output per hour is 40 to 50 tons



CELLULOID PRESS OF 3,000 TONS, FOR POLISHING CELLULOID SHEETS OF 5 FT. X 2 FT. CAPACITY
HENRY BERRY & CO., LTD., CROYDON WORKS, LEEDS

This press carries 16 loose plates fitted with telescopic pipes to admit water or steam for heating or cooling.

fourth position, where a small ram, exercising a power of 10 tons only, forces the flag and loose plate out of the mould and through a hole in the fixed table below to a trolley beneath. Flags are produced at the rate of nearly one a minute, four men or boys being employed, one being located in each position. The machine weighs 32 tons, and includes pumps, accumulator and intensifier. By the substitution of different moulds, flags



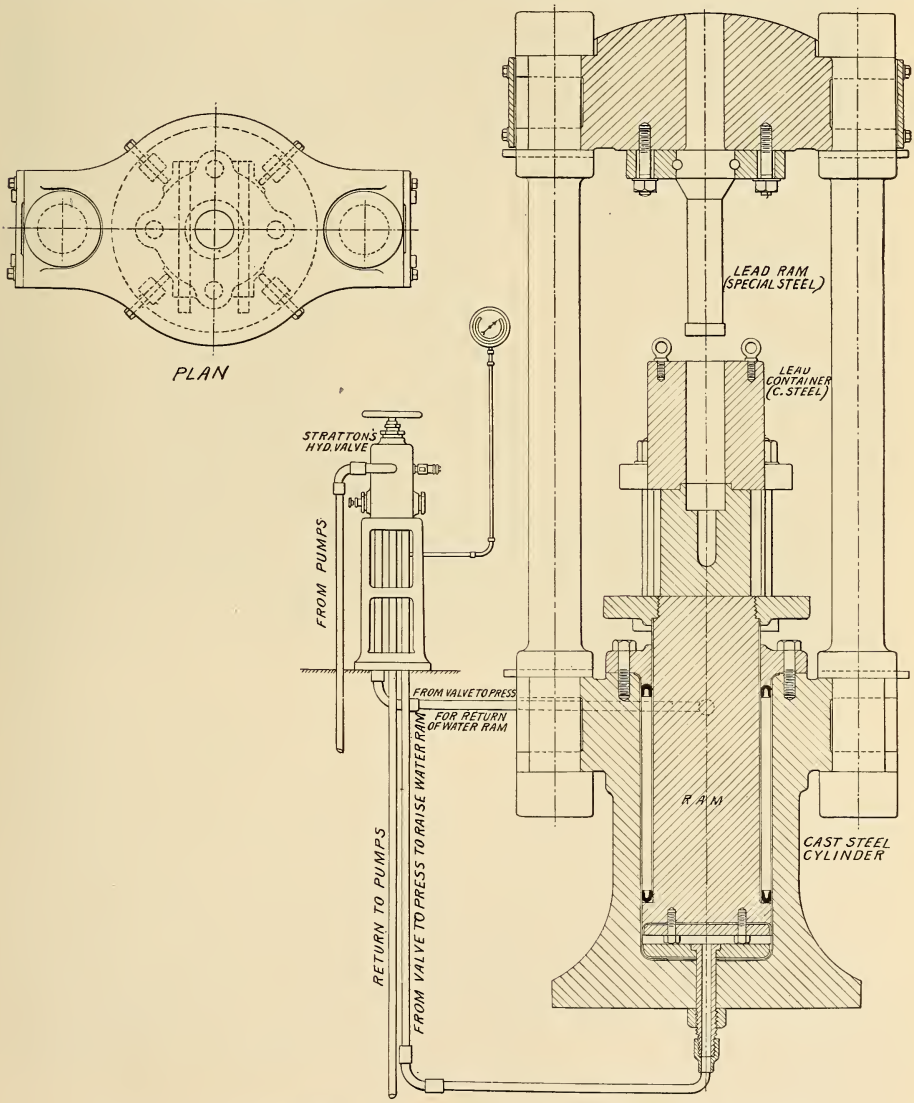
SIX-POWER HYDRAULIC FLANGING PRESS FOR PRESSING WAGON SIDES COLD, WITH MAXIMUM POWER OF 2,000 TONS. RICE & CO., LTD., LEEDS

can be made, ranging from 2 feet by 2 feet to 2 feet 6 inches by 3 feet by 2½ inches thick.

Let us now glance at the machines employed in the boiler and plating shops. Take bending, for example. First, the horizontal bending rolls have been improved and strengthened. When wide steel plates, of from 1 inch to 1½ inches thick, have to be bent cold, rolls will inevitably spring. Hence rolls are turned bellied, or they are kept to their work by friction rolls or intermediate bearings. Then in the ordinary arrangement a plate cannot be bent to the last three inches or 4 inches next the edge, except in machines where the top roll is set vertically over one of the bottom ones, with the third adjustable roll at the side. The difficulty of supporting long and heavy plates in a horizontal position is also a serious one. For very heavy work, therefore, this design is superseded by the vertical rolls. But in each design the drive is by belt only, or by an independent steam engine. But

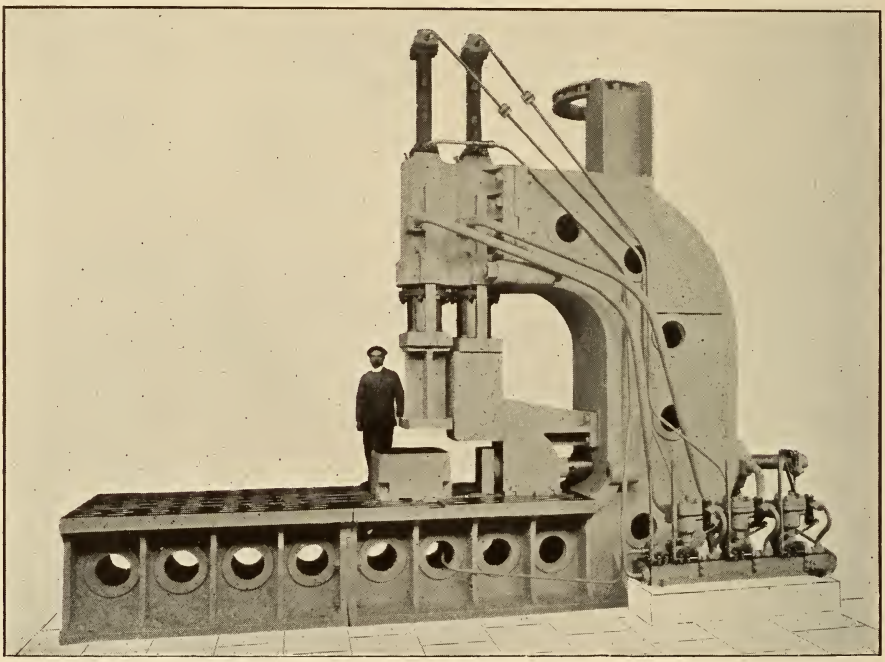
the hydraulic plate bending machines have come into rivalry with both. The plates are set on edge and squeezed in detail between girder-like frames, one being fixed, the other movable, by an hydraulic ram coupled to rollers running up inclined planes. Lengths of about 3 inches at a time are bent, and bending is done right to the edges, and butt straps can be dealt with similarly.

The work of flanging does not stand where it did when plates and sections were lighter. Such work was often done in successive lengths; but with the exceptional cases of very large plates, it has now, and for a long time, been performed at one heat. All locomotive firebox plates are so flanged, and the end plates of Lancashire boilers, the crown plates of vertical boilers and fireboxes, the ends of compressed air cylinders, and other work of which these are typical. Dies large enough to deal with the entire plate are cast and at-



HYDRAULIC LEAD PIPE PRESS. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

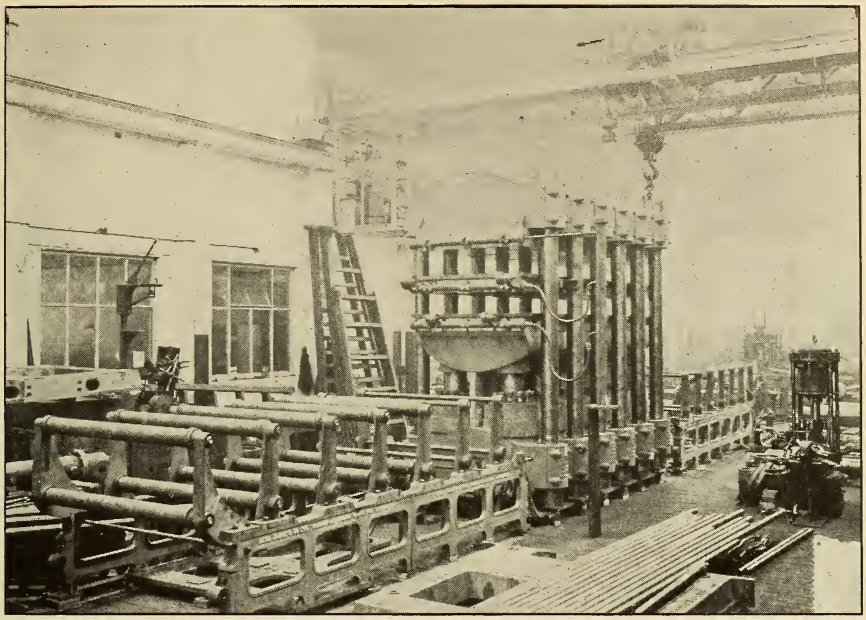
tached to the machine, and the entire piece is flanged at a single squeeze. The forms in which machines of this class are built are now extremely numerous and varied. In this sphere hand work is practically all abolished. Water saving devices are adopted when practicable. Many machines of this kind are built specially for dealing with heavy forgings pressed in dies. They may have one, two or three separate rams, by which resettings of intricate work are avoided.



HYDRAULIC FLANGER PRESS, WITH FOUR RAMS FOR MARINE BOILER ENDS UP TO 20 FT. DIAMETER, BY 2¼ IN. THICK PLATE. RICE & CO., LTD., LEEDS

Work is pressed to outlines, large holes of any shape punched, edges flanged, welds made—all performed by the movements of a ram or rams at the pressures for which the machines are built, which covers a very wide range.

Besides the machines which flange a plate at one heat and one squeeze, there are two other groups which do the work in detail. The first deal with the plates of marine boilers, which are too large to be flanged at one heat; the second roll the flanges of furnace flues forming the Adamson seams. In the first kind of machine a few inches in length is flanged at a time, the flange being turned downwards by a descending ram and die block, while the plate is prevented from moving by a ram in front. After several feet have been thus treated the flange is neatly corrected by a horizontal ram and die block. The flanges of Adamson seams, at first turned over by mechanism of belt and gears, are done in some later machines by hydraulic pressure. Boiler tube upsetting and thickening are effected in hydraulic staving presses at one squeeze. The tube is held in gripping dies by a vertical ram, while the horizontal ram comes up and opens the end, causing it to fill the dies. Such work would be extremely slow and very unsatisfactory if attempted by hand. Hydraulic bending is utilized in dealing with ships' plates, in bending sections of all kinds to all curves between three points, in pressing steel



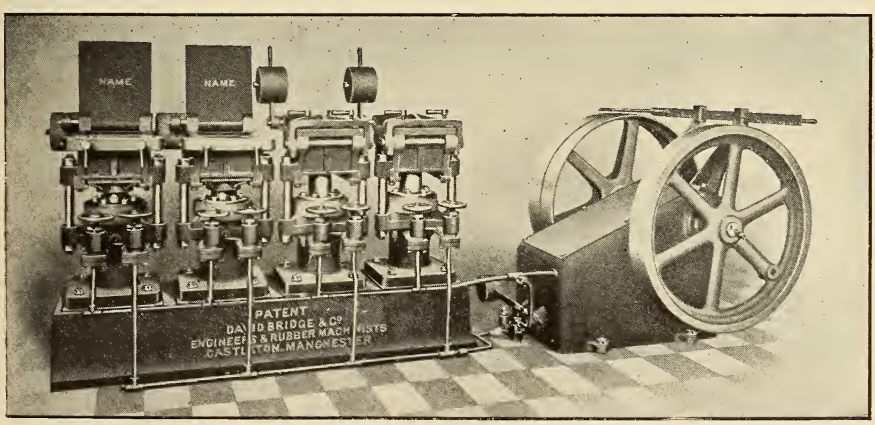
LARGE 12-RAM VULCANIZING PRESS, BUILT FOR THE PREMIER REFORMING CO., LTD., WALTHAMSTOW. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

Total pressure on platens is 3,000 tons.

boats, bending bridge floors, in forging solid drawn steel shells and cartridge cases, in tube drawing, in all of which spheres it seems to be entrenched securely.

Hydraulic riveting can only be mentioned. The designs of the machines used are far too numerous to be even stated. The development of this work has been a marvelous one, and now there is hardly any riveting, however awkwardly situated, which cannot be dealt with by machines. Punching and shearing have long been appropriated by hydraulic machines, formerly all steam-driven. This work is now much heavier than it was, and the heavier it becomes the better does pressure water score over steam.

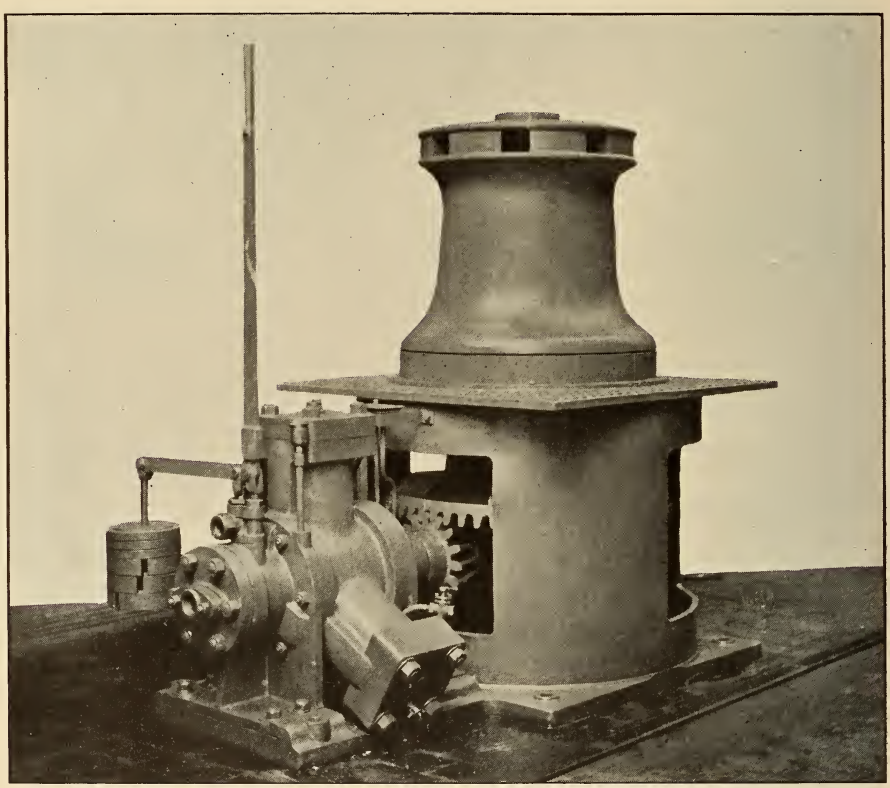
In heavy testing machines hydraulic power has no rival. The



BATTERY OF PATENT HYDRAULIC RUBBER BLOCKING PRESSES WITH PUMPS. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

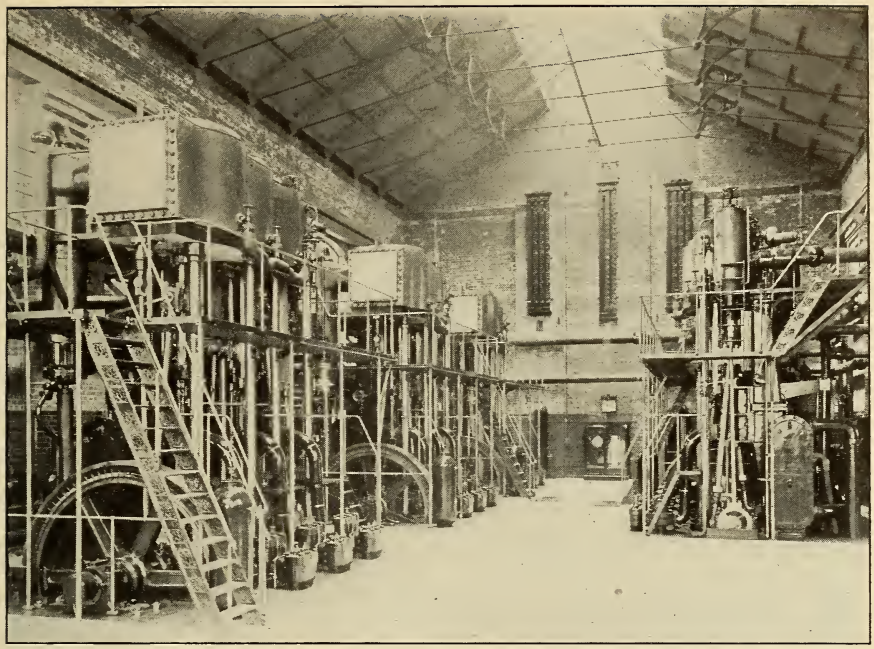
first large testing machine built by Mr. Williams in 1829 for 130 tons load was operated by two hydraulic cylinders raising the crosshead. The latest and most powerful machine at Lloyd's Bute proving house, a 350-tons machine, in which the cables of the *Mauretania* were tested, is actuated by pressure water. It will test anchors 17 feet long in the stem. A 300-ton machine for the French tubes and boilers are always and necessarily tested by water pressure, reading off on gauges.

Hydraulic supply is eminently one for central station work rather than for private enterprise. Mr. E. B. Ellington established the first in Hull in 1875. Later he has been associated with the public supplies of Manchester and Glasgow, as well as of London, commenced in 1874. In the



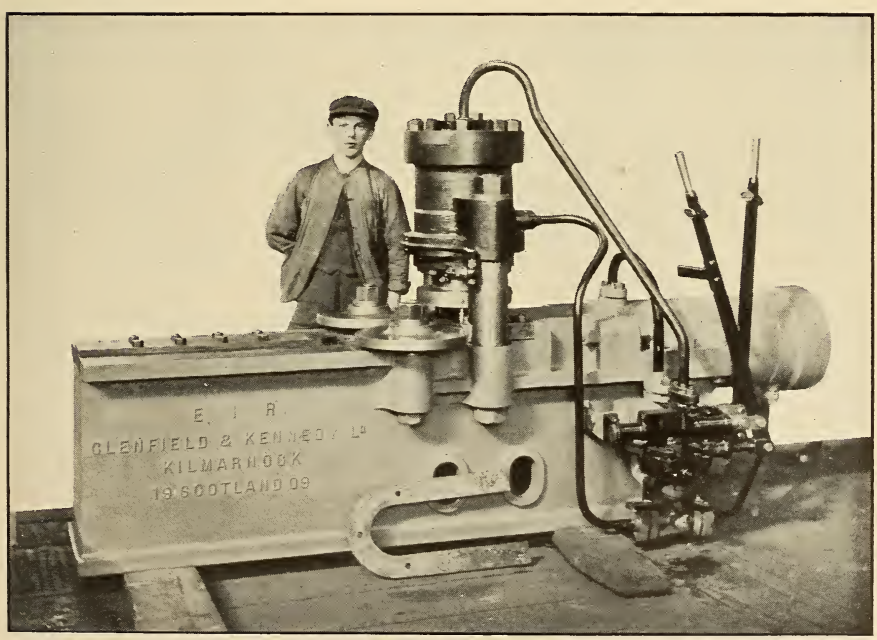
SINGLE POWER 3-TON GEARED CAPSTAN, DRIVEN BY BROTHERHOOD HYDRAULIC ENGINE. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

Government, which will take columns up to 80 feet in length, is also similarly operated. For such machines the control of the accumulator permits of rapid movements, or of slow straining when the critical load is approached. Mr. Wicksteed has remarked that, while pumps can be varied in speed 4 to 1, the flow of water through a valve can be more easily varied to 100 to 1. Pipes and two former towns the pressure is 1,120 pounds per square inch; in London it is 750. At the present time there are 174 miles of hydraulic mains down in London, and 21,900,000 gallons are delivered weekly to 6,910 machines. The water is taken from the Thames, the Regent's Canal, and from wells, and sediment is removed by filtration before it is delivered into the mains. It supplies



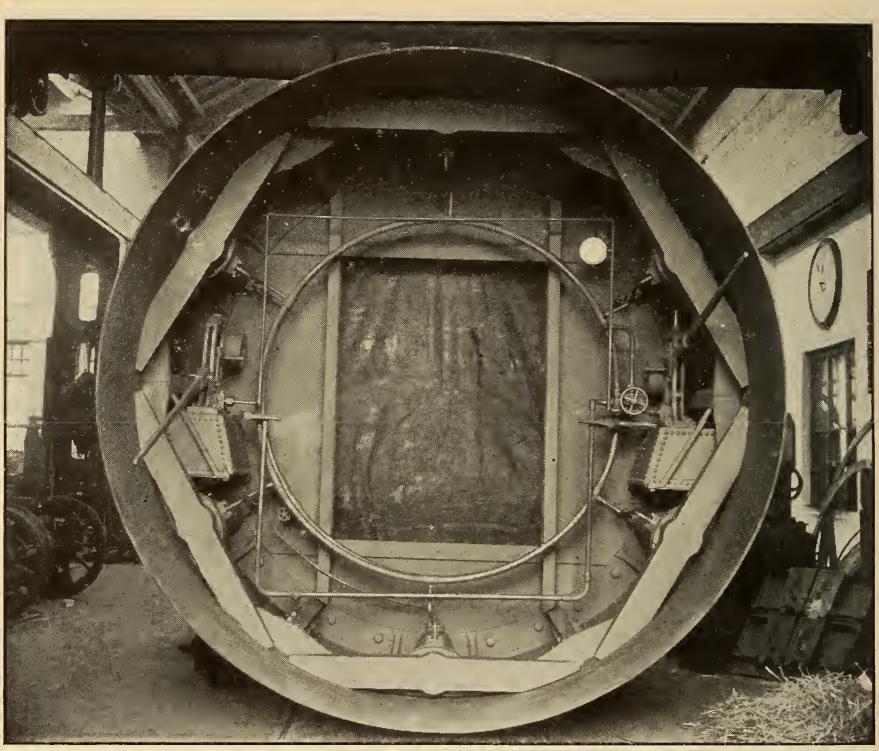
INTERIOR VIEW OF ENGINE HOUSE, SHOWING TRIPLE-EXPANSION PUMPING ENGINES. GROSVENOR ROAD PUMPING STATION, LONDON HYDRAULIC POWER CO.

Each engine delivers 26,000 gallons of water into the mains at a pressure of 820 pounds per square inch—boiler pressure 180 pounds per square inch.



HYDRAULIC AXLE GUARD BENDING AND PUNCHING MACHINE. GLENFIELD & KENNEDY, LTD., KILMARNOCK, SCOTLAND

Working pressure 1,500 pounds per square inch. Test pressure, 3,000 pounds per square inch.

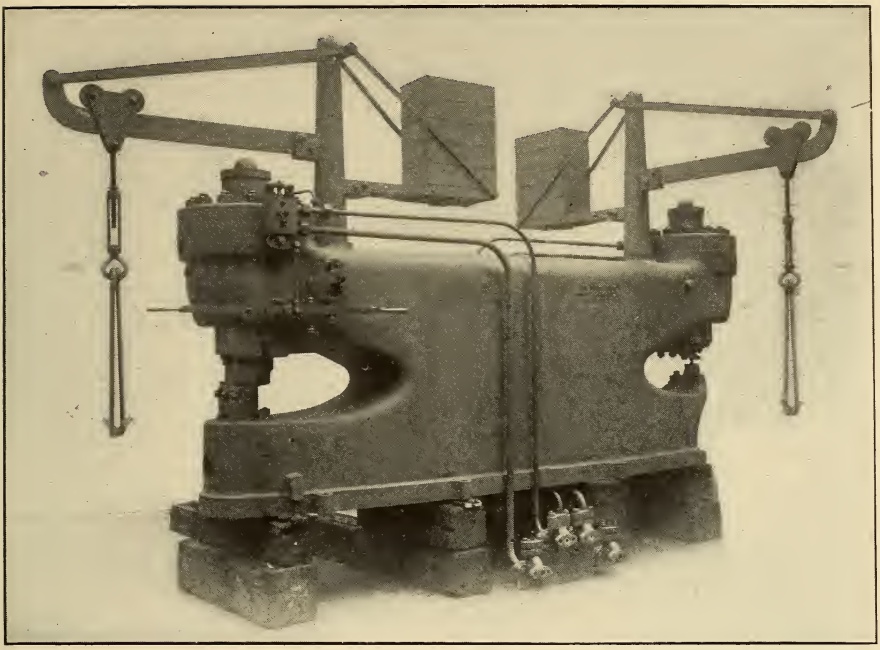


ORDINARY GREATHEAD HYDRAULICALLY OPERATED SHIELD, 4 FT. 8 IN. DIAMETER, AS USED IN CONSTRUCTION OF THE ORIGINAL CITY & SOUTHWARK RAILWAY (NOW CITY & SOUTH LONDON RAILWAY). MARKAM & CO., LTD., CHESTERFIELD

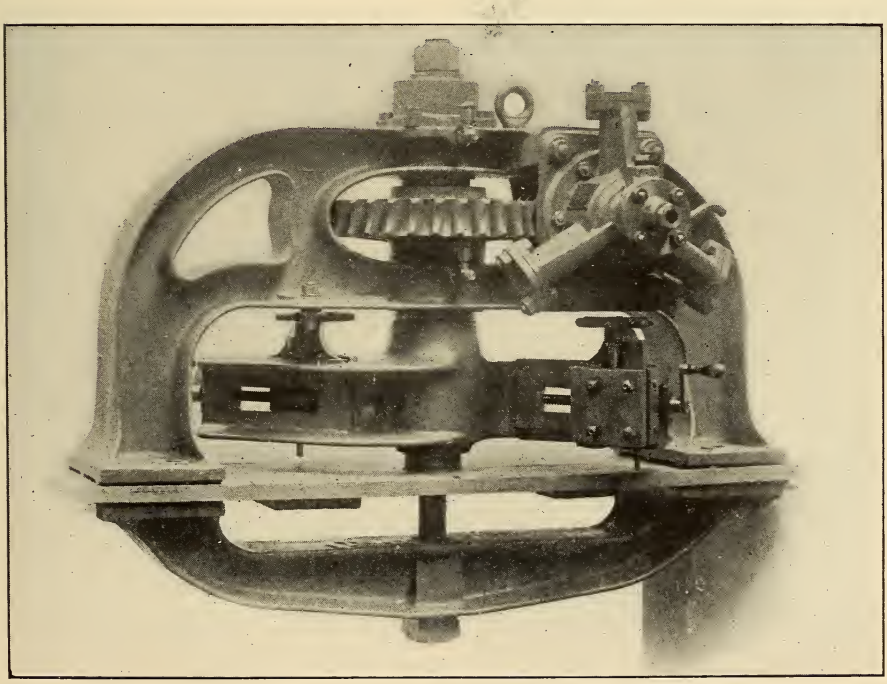
cranes, lifts, turbine motors for producing rotary motion for chaff cutting, conveying plant, etc., organ blowing, pumps for deep wells, ejectors, fire hydrants, presses, directly connected to the mains or with intensifiers for producing higher pressures.

There are five central pumping stations, situated from two to three miles apart. At each there are two accumulators, having rams of 20 inches diameter and 23 feet stroke, loaded with a weight of about 80 tons. One is loaded slightly heavier than the other, so that it descends to the full length of its stroke before the other commences its descent. The latter is, therefore, a reserve only to meet a sudden demand for power if the capacity of the first or working accumulator should be overtaxed. Each power house contains pumping engines of triple-expansion surface condensing steam pumping type, working at a steam pressure of 180 pounds per square inch. The equipment includes settling reservoirs, boilers with water softening plant, feed pumps and filters and coal stores.

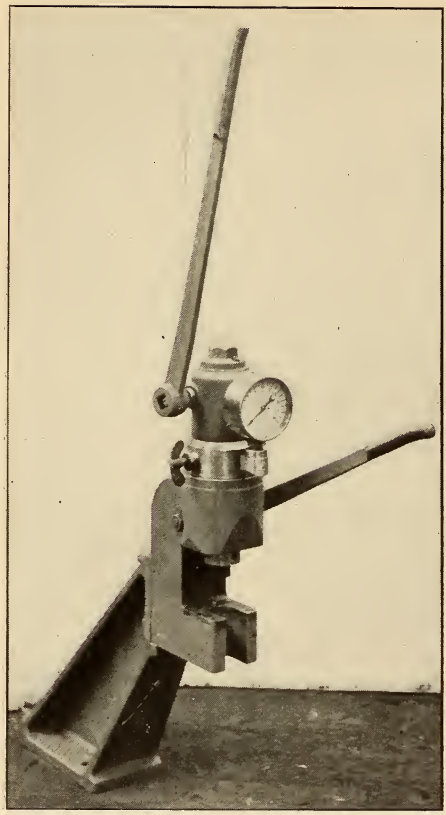
The mains for supply range from 6 inches to 10 inches bore. Mr. Ellington's flanges have become historic. Previous flanges broke: these do not. They are not only 3½ inches thick, but are cast back from the ends of the pipes so that when screwed up there is a space of 2 inches between them. Leakages are rare: they are too serious to take the risk of. Spongy metal would be fatal. A hole 5/16 inch in diameter would waste 3,000 gallons per hour, equivalent to 15 horse-power lost. The engines are stopped or started as the demands for power vary. This rises from 6 A. M. to 10 A. M.,



TRIPLE HYDRAULIC MACHINE FOR PUNCHING AND SHEARING 1-INCH PLATES, AND 4-IN. X 4-IN. X ¾-IN. ANGLES. THE HYDRAULIC ENGINEERING CO., LTD., CHESTER



PORTABLE HYDRAULIC MANHOLE CUTTING MACHINE, DRIVEN BY BROTHERHOOD ENGINE. THE HYDRAULIC ENGINEERING CO., LTD.



HYDRAULIC 10-TON PRESS, USED FOR SQUIRTING METALLIC FILAMENTS FOR INCANDESCENT ELECTRIC LAMPS. TANGYES, LTD., BIRMINGHAM

lessens between 12 and 2, goes on till 4, and then declines to midnight.

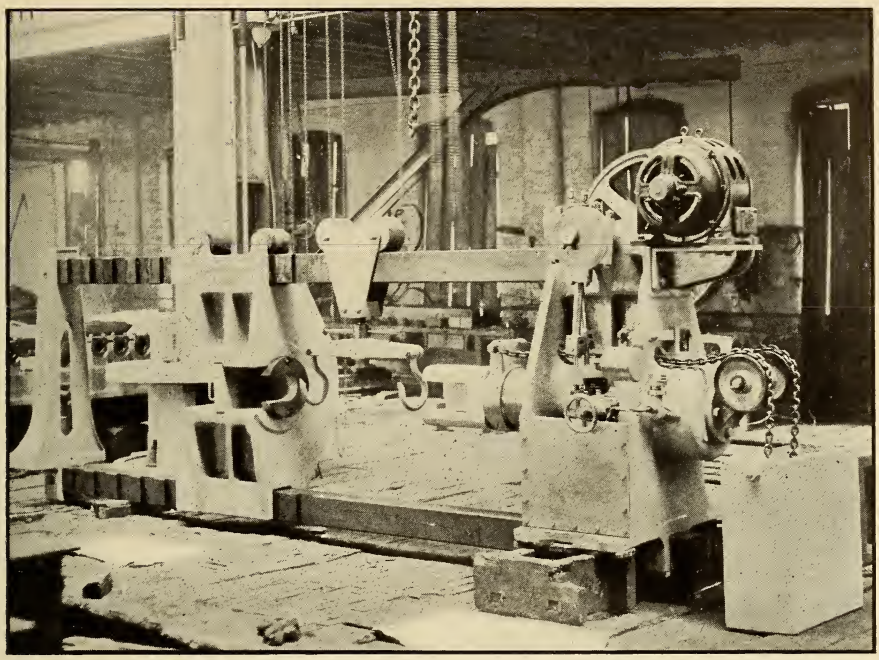
The water supply is measured before it is distributed to the mains by Venturi-meters, and at the customers' ends by service meters. The pipes are laid underneath the streets below reach of frost, and are slightly warm. Supply can be taken at pressures lower or higher than the 750 pounds in the mains. If at a lower pressure, a reducing valve is fitted to the service pipe, which is controlled by a small accumulator loaded to the weight corresponding with the low pressure required. The movements of the accumulator also control the supply; its full ascent closes and its descent opens the supply valve. If a higher pressure is required an intensifier is used.

To prevent the effects of shocks spring momentum valves are placed on mains, the springs of which absorb the shocks, but do not permit water to escape. This last is the function of another set of valves—the relief valves—which, when the pressure rises above a specified amount, allow the water to escape. These are either spring or weight loaded.

Rotary motion is required for actuating centrifugal pumps, ventilating fans, organ bellows and machinery of many kinds. These demands are provided for by using water from the hydraulic mains, either through the medium of Pelton wheels or of three-cylinder engines. Both are suitable for very wide ranges in pressures—Pelton wheels from 10 pounds to 1,200 pounds, three-cylinder engines from 60 pounds to 1,500 pounds. The differences in the latter are only those of less or more strong proportions.

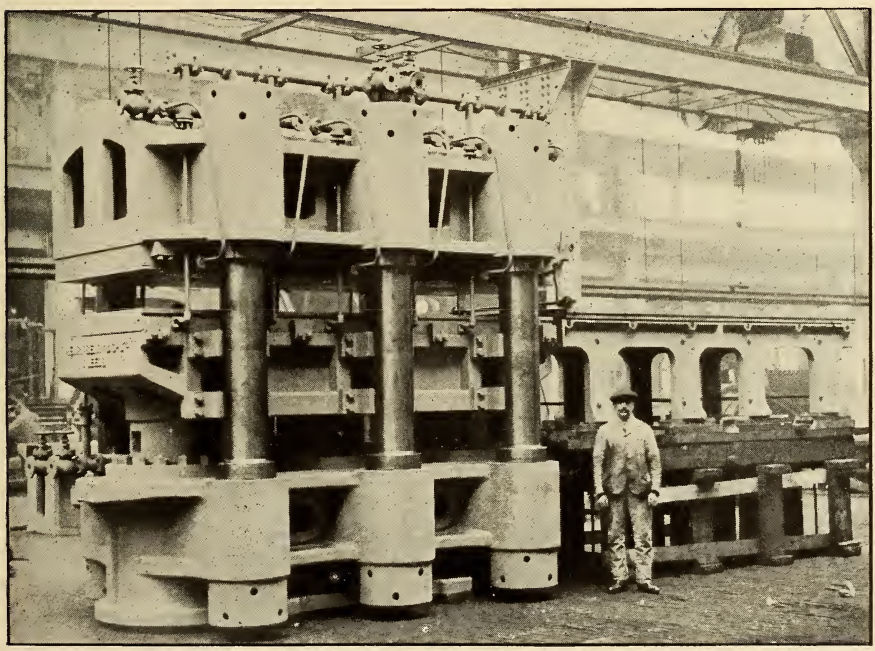
The high-pressure water is used in the form of the injector for fire extinction. By passing a current of it through a flow of water at ordinary pressure the latter receives a high velocity, which will thus travel very much farther than the ordinary service water will do.

Pumping engines are made in many designs, to suit all conditions. The highest grade is represented by the horizontal three-throw design, built either compound or triple-expansion. The balancing is good, the supply of water practically uniform, and the engines are economical. In the Ellington engines, made by the Hydraulic Engineering Company for the London Hydraulic Power Company, surface condensation is included. The cylinders are jacketed, including the cover of the low-pressure cylinder. The pump rams are of gun metal. At a piston speed of 208 feet per minute each set of engines delivers 250 gallons per minute against an accumulator pressure of 800 pounds per square inch. Tandem compound engines are made, in which the pumps are placed at the



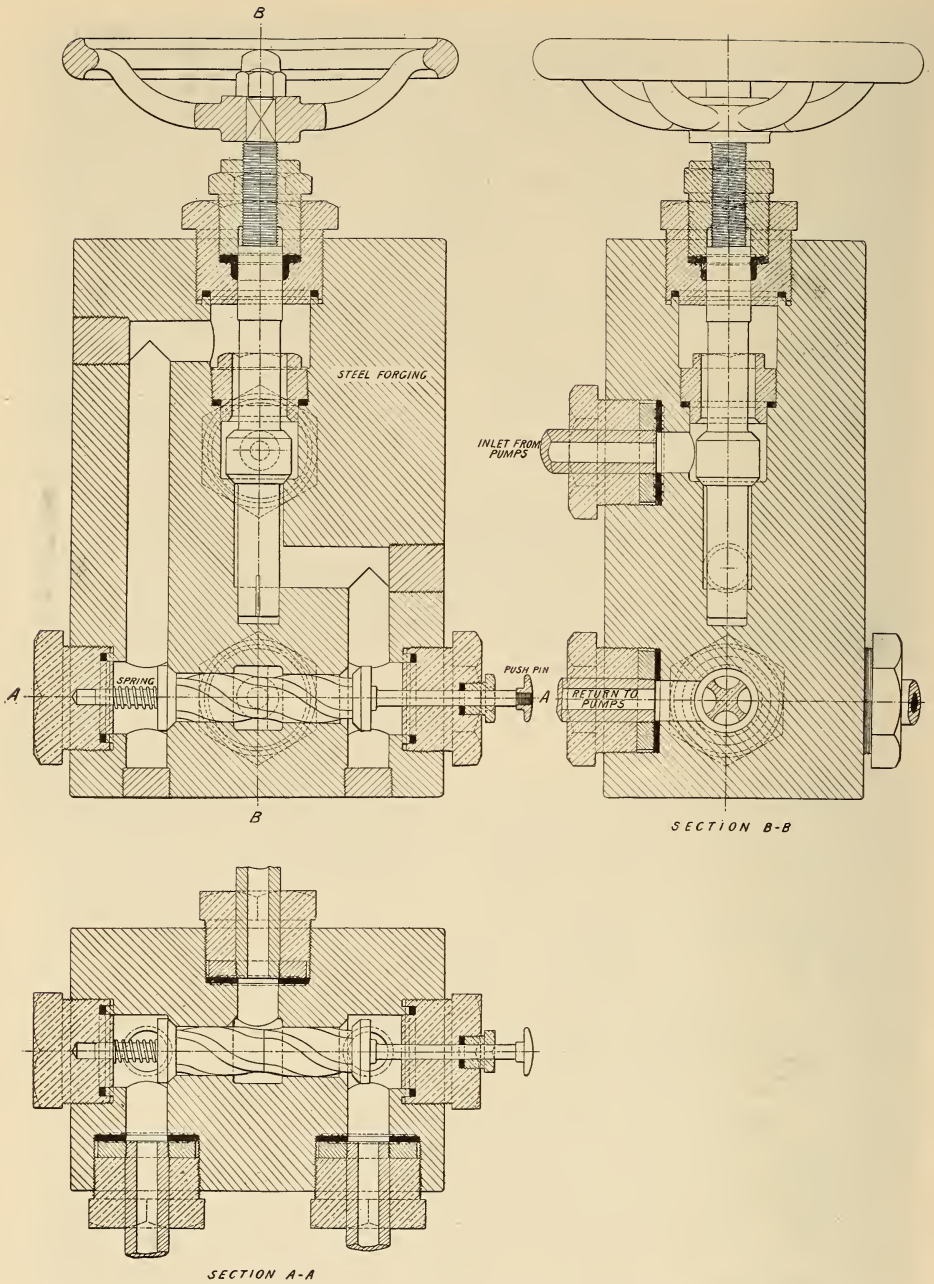
HYDRAULIC 300-TON WHEEL PRESS, WITH ELECTRICALLY DRIVEN PUMP OF 10 BRAKE-HORSEPOWER.
HENRY BERRY & CO., LTD., LEEDS

Admits wheels up to 4 ft. diameter, and can be used for putting on or taking off their axles



HYDRAULIC VULCANIZING PRESS, WEIGHING 4,000 TONS. HENRY BERRY & CO., LTD., LEEDS

Capacity 12 ft. x 4 ft. Has steam-heated plates fitted to head and moving table.
Plates and pipes are arranged so that either steam or water can be admitted
to the plates for heating or cooling.



STRATTON FOUR-WAY HYDRAULIC VALVE. DAVID BRIDGE & CO., LTD., CASTLETON, MANCHESTER

back of the low-pressure cylinders and are driven directly by prolongations of the piston rods.

Among the numerous hydraulic engines none have been employed so much as the Brotherhood three-cylinder type. These are used most extensively for capstans, and, making the capstan of the turnover design, the engines can be brought uppermost for the purposes of examination and repair. Sometimes they have

run for a twelvemonth without this.

For a good while past the hydraulic engineers have been fitting electric motors in place of steam engines to horizontal pumps. The reduction is effected by spur gearing. In electrically-driven pumps by the Hydraulic Engineering Company a continuous-current motor of 500 volts makes 825 revolutions per minute, reduced at the crankshaft to from 36 to 50 revolutions per minute in different pumps. A rawhide pinion on the motor shaft engages with a cast-iron, machine-cut spur gear, thence the drive is completed by double helical steel gears. Three-throw vertical pumps are driven similarly, the general model being that of the older belt-driven pumps.

The difficulties in using water increase with increase of pressure. With good workmanship ordinary materials can be employed up to 750 pounds or 1,000 pounds to the square inch. Good, close-grained cast iron for cylinders and ordinary gunmetal for cocks and valves are quite suitable. This meets the case of most crane work. But for compression duty, as in forging and baling presses, and in the pumps and valves for working the same, iron and gunmetal are useless. In the large cylinders for the Belgian canal lifts cast iron was used, bonded with steel rings. These were worked at a pressure of 517 pounds per square inch (thirty-five atmospheres). When pressures range from 2 to as much as 4 tons per square inch—say 300 to 600 atmospheres—the conditions are vastly more severe and exacting.

These enormous pressures explain why valves wear rapidly and why escape valves must be fitted to long lengths of pipe. A small valve will have many tons of load on it with high unit pressures on the seats, so that they are subject to intense shocks. Long pipes must have escape valves, because, though water is practically incompressible, it is not wholly so, and the pressure on the pipes tends to enlarge them, and so there is considerable shock when opening and closing valves to long solid masses of water. The difficulties which arise in connection with hydraulic valves increase with high pressures. Any error, therefore, in operating the separate valves for supply and exhaust when pressures reach two or three tons per square inch is liable to bring about serious results. Fool-proof devices are adopted to prevent the opening or closing of the wrong valves, but the difficulty then is to ensure equal wear on the different seatings, which is practically impossible. The slightest leakage soon scores the seating badly. The Stratton valve, made by Messrs. David Bridge & Co., Ltd., is a successful attempt to couple all the valves of a press without giving trouble consequent on unequal wear. It provides for changing the pressure by the valve from one end of the press to the other, and also for controlling the supply from the pumps to the valve and from the valve to the pumps. The valve is controlled by one handwheel. It has two internal reciprocating valve stems at right angles, each stem controlling two valves. The main stem, with its two valves, controls the entrance of the water into either one of two separate channels, which communicate with one or the other of the second pair of valves. These cannot be both closed at one time, the valve stem being too long to permit of this. A coiled spring keeps one normally open, the other closed; but the pressure of the spring is overcome by a push pin, thrust by the attendant when that valve is required to be open. It is easily seen, without detailed description, that these arrangements permit of reversing the action of the ram by the movements of the main valve stem, and of controlling the direction of movement of the incoming and exhaust water.

MECHANICAL APPLIANCES ON THE PANAMA CANAL

V.—LOCK CONSTRUCTION AND OPERATION

By J. F. Springer

The closing installment of Mr. Springer's articles on the Panama Canal includes some account of the immense concrete locks, together with the appliances for their operation, and also some comments upon the canal considered as a whole. The series of articles as thus completed probably forms the most complete account of the extent to which this great undertaking has shown the use of machinery for the performance of work formerly done either by hand or by crude appliances of moderate capacity. Panama has proved itself to be a school in sanitation, in transport, in conveying materials, and in concrete construction, and apart from the great result which has been achieved, it has rendered the next undertaking of the kind far simpler and more practicable.—The Editor.

The unloading of the vessels which bring the cement from New York to Cristobal is a matter of considerable magnitude. In October, 1908, delivery was yet to be made of an amount equal to more than 4,000,000 barrels. This was cement for which contract had already been made. It was expected that most of this material would be brought to the Isthmus by the steamships *Ancon* and *Cristobal*. These vessels were making one round trip each per month. Each could be depended on to bring 25,000 barrels of cement a trip. It will then be seen that about eighty months (six and two-third years) would be required to deliver the contracted amount. Part of the cement is brought in barrels, part in bags. That which is brought in bags, it was expected, would be shipped by rail (via Panama Railroad) to Pedro Miguel, Miraflores or other points. The cement in barrels it was proposed to send by barge to the cement shed near the Gatun Locks. The *Ancon* and *Cristobal* are twin vessels, so that the arrangements and dimensions are identical.

With the exception of Hatch No. 4, counting from forward, all the hatches have the dimensions 17⅓ x 20 feet. Assuming that the plans have been strictly followed, six hatches of each ship have been fitted with mechanical conveyors for the purpose of unloading. Hatches Nos. 1 and 4 are reserved for cement in bags; Hatches Nos. 2, 3, 8 and 9 for cement in barrels. According to the plan in 1908, there were to be vertical conveyors—one to each hatch—running from the bottom of the hold to the hatch opening. These were to deliver to the other conveyors, which were then to transport the material to barge or railway platform. A moment's consideration will convince one that these latter conveyors would have to have a certain amount of flexibility. The steamship unloading will constantly rise higher and higher out of the water; the barge being loaded will constantly sink deeper. The barrel conveyors would have to be especially flexible, because of the opposite tendency of both these movements. The bag conveyors would also have to be flexible, but not to the same extent. The bag-conveying apparatus was to consist of these elements—the vertical elevator, a portable conveyor of the apron type and a stationary conveyor. The portable apparatus was to convey the bags from the elevator across the side of the ship to the third element. The portable conveyor was to have two towers, by means of which the elevation of the aprons could be adjusted from time to time to suit the changing conditions. The alteration in level that would have to be compensated for is 12 feet. The third element was to be a stationary conveyor running parallel with the side of the ship, by whose means the bags were to be carried lengthwise of the railway pier. The unloading device for the barrels was to consist of two ele-

ments—the vertical elevator and a transverse conveyor, by means of which the barrels received from the first element could be carried over the side of the ship and deposited in the barge. An adjusting tower belonged to this element. The only points of the whole system at which hand labour was to be employed were the following: (1) in the hold of the ship; (2) at the points of final discharge at the railway car and in other end overhangs the barge. A sprocket wheel is arranged at either end of the truss. Upon these an endless carrying device, consisting of two parallel roller chains supporting chain loops, is operated. The loops are so secured to the chains with movable joints that the barrels are held secure from hold to barge. The total distance of transportation may be 125 feet. The necessary adjustment is secured, in part, by means of

UNLOADING CEMENT FROM THE ANCON AT CRISTOBAL, TO BE SHIPPED BY RAIL TO PEDRO MIGUEL

the hold of the barge. Upon testing out the design—at least, that portion concerned with the unloading of the barrels—the results were unsatisfactory to those in charge. The engineers of the Canal Commission also designed an unloading device which seems to have given good results. An endless chain is operated in such a way as to raise barrels out of the hold and deposit them in the barge alongside the ship. On the deck of the ship a truss, 45 feet long and made of structural steel, is arranged. One end overhangs the hatch; the hydraulic jacks arranged to act against the lower side of the truss. Adjustment may also be made by lengthening or shortening the chain by means of removable links. Another method of holding the barrels which have been tested is by the use of hooks instead of chain loops.

The method of handling the cement, sand and stone at the southern end of the high-level section of the canal is radically different from that employed at Gatun Locks. The cement comes by rail. So also do the sand and stone—at least, in part.

There are two principal construction points—the pair of locks at Pedro Miguel and the two pairs at Miraflores. The conditions are such that it was decided to employ a type of crane. In fact, two varieties of cranes are employed. One of these is the berm crane, so called because these apparatus travel on tracks arranged on berms. The office of this device is to move from point to point of the piles of sand and stone and gather these materials to a central point within itself where they are mixed with water and cement to form concrete. The other variety of crane is the chamber crane. This piece of apparatus moves longitudinally in a lock chamber. It distributes concrete from a central point, where it receives this composite material that has been mixed at the berm crane. A little railway transports the concrete from the one crane to the other. In the forebay at the northern end of the Pedro Miguel Locks two trestles, having an average height of 28 feet and a length of 800 feet, have been constructed to facilitate the storage of sand and stone. These trestles are situated to either side of the site of the wall which will divide the forebay into two channels. Dump cars, having a capacity of 12 cubic yards each and loaded, some with stone and sand, are run out on these trestles and their contents dumped. The stone is dumped on the inner sides of the trestles and the sand on the outer sides. Between the two long and parallel piles of material two parallel tracks are laid. Each track is of 5-foot gauge, and the two tracks are 50 feet apart from central axis to central axis. Upon this pair of tracks a steel tower, perhaps 90 feet in height, is mounted on sixty-four wheels—thirty-two wheels per track. There are two box girders, each of which is provided with sixteen axles. Upon these girders the tower is supported. The tower itself is 50 feet wide and 40 long. From each side near the top a cantilever arm projects to a distance of 150 feet, overhanging, in fact, a pile of sand and stone. These cantilevers are rigidly fixed to the tower. From the tops of the rails to the bottoms of the cantilever arms the distance is 62½ feet. At the extreme top of the tower and above the summits of the arms is the operating machinery. In the tower, but beneath the level of the cantilevers, the mixing apparatus is installed.

There is a very considerable vertical space between the two. Just above the mixing machinery are located sand and stone bins. These are served by two trolleys, running one on each arm. By means of these trolleys, which are underhung, Hulett excavating buckets are operated. These have a capacity of 2½ cubic yards each and bring the sand and stone to the bins. The bins are four in number and have a combined capacity of 60 cubic yards. Underneath the bins the whole plan area of the tower is devoted to a cement floor. Here 6,000 bags of cement may be stored. Two cement hoppers, having a combined capacity of twenty barrels, depend from this floor. Cement is brought to the foot of the tower by a spur from the Panama Railroad. From the railway car the bags are mechanically elevated to the level of the cement floors and deposited on a horizontal conveyor. The apparatus carries the bags to a grating over the cement hoppers. The bags may, however, be removed and stored, if desired. There are two concrete mixers to each tower. These are, of course, located below the sand and stone bins and the cement hoppers. The mixers are "cube" machines, and have a capacity of 2 cubic yards each. Electric motors drive these machines. Recording instruments operated by electricity indicate graphically the time occupied in mixing a batch of concrete. Automatic measuring tanks arranged on the towers control the water supplied to the mixers of the berm cranes. With the exception of the mixing motors, all

SIDE VIEW OF THE ANCON, SHOWING BARREL CONVEYORS FOR CEMENT

the electric power machinery is located at the top of the towers. Each trolley, however, has its own cab and its own operator in immediate charge of the bucket. By means of master switches these operators are enabled to control their buckets. The hoisting is, of course, the severe operation. For this a 65 horse-power motor is provided. The movement along the cantilever arms is effected by a 21 horse-power motor. A 15-horse-power motor drives the elevator and conveyor, and one of 40 horse-power operates each mixer. There is thus a grand total of 282 electric horse-power to each crane. When it is desired to move the crane itself along its double track one of the hoisting motors is used to supply the power. To perform this operation a friction clutch arrangement is thrown to disengage the hoisting drum and to engage the traversing drums. These latter drums are arranged at the top of the towers. Steel ropes pass to deflecting sheaves arranged at the top and bottom of the towers. The ropes pass off to "deadmen" placed alongside the tracks. Seven hundred feet of movement may be given to the cranes. The electric arrangements provide that when the current is given to the traversing drums it is cut off from the hoisting apparatus.

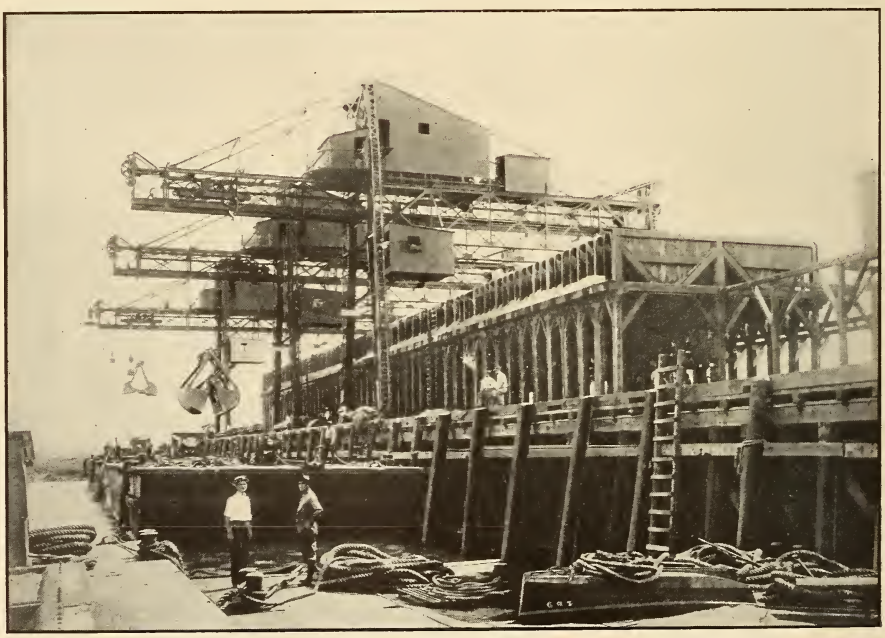
The chamber cranes are somewhat similar in general appearance to the berm cranes. They are, however, not the scene of manufacturing operations, and so are somewhat simpler. There is a central skeleton tower from whose top two cantilever arms extend to either side. The vertical distance from the tops of the rails to the bottoms of the cantilevers is 97½ feet. The arms are designed to overhang the sites of the lock walls. The inner arm extends 53½ feet to the central vertical plane of the wall which divides the pair of locks. The outer arm extends well over the site of the side wall, a distance of 81½ feet. As the tower is 56 feet wide, the distance between the outer extremities of the cantilevers is 191 feet. A continuous un-

derhung trolley line extends throughout this distance. Buckets of two cubic yards capacity each are carried to and fro, and thus accomplish the service of distributing the fresh concrete to the points of use. The towers run on a pair of tracks consisting of two rails placed 5 feet apart. From centre line to centre line of the companion tracks the distance is 40 feet. The legs of the towers straddle the railway lines which bring the concrete. As with the berm cranes, these chamber cranes may be moved longitudinally along their own tracks. The plan was to use the equipment of berm and chamber cranes at Miraflores also.

The two berm cranes were to be somewhat modified and two others added. Two are used on tracks extending along the exterior of one side of the locks and two on tracks on the other side. Only their exterior arms gather sand and stone from piles placed exterior to the tracks. The inner arms can be used for transporting the concrete mixed in the towers either to the outer walls of the lock chambers or to the chamber cranes. There is thus no railway required to transport from bern crane to chamber crane. The inner arms of the berm cranes differ from the exterior arms in being a little shorter, but more especially in respect to their capability of being depressed or elevated. A considerable vertical range is thus provided, permitting an advantageous serving of the lock walls at different stages of completion. The arrangements are such that the movable arm can be adjusted to clear the chamber crane when the one machine needs to pass the other. It has been estimated that the capacity of the equipment is the delivery of 100 cubic yards of concrete per hour per crane. The work of laying concrete at Miraflores began before the transfer of the Pedro Miguel equipment. It was thought possible that for this reason only two of the chamber cranes might be required for the work on the upper locks.

THE CRUSHING OF THE ROCK

There are two great quarries supplying the canal with stone for the



SAND LOADING CRANES. THE CLEVELAND CRANE & ENGINEERING CO., WICKLIFFE, OHIO

concrete works and other construction. Both are on the sea. On the Atlantic side the quarry at Porto Bello is the point of supply. Previous to the construction of the Panama Railroad in the middle of the nineteenth century, Porto Bello was the Atlantic shipping point for traffic crossing the Isthmus. There is a small town and a very fine harbour. A pretty little bay, 1½ miles long and ½ mile wide, opens out upon the Caribbean Sea. Over pretty much the whole of the harbour the water has a depth ranging from 30 to 90 feet. Porto Bello is, perhaps, 10 or 12 miles east of the canal zone, and in the territory of the Republic of Panama. On the east side of the entrance to the harbour is the hill which contains the rock. An estimate based on extensive borings places the available quantity of rock at 20,000,000 cubic yards. This is very much more than will be required. It is estimated that the breakwater at Limon Bay will absorb about 4,500,000 cubic yards and the concrete works at Gatun about 2,250,000 cubic yards, or about 7,000,000 cubic yards in all. The rock is "a massive andesite with a specific gravity of about 2.70, crushes readily, and is well suited for concrete." A great advantage at Porto Bello consists in the location of the rock. Gravity supplies the power for transportation from quarry to crusher and from crusher to conveying system.

The overlying earth is stripped off by hydraulic means. A 10-inch main runs from the bay up to the 265-foot level. Through this water is forced by a pump having a capacity of 1,500 gallons per minute "against a static and friction head of 460 feet." The stream for stripping is delivered through a 2-inch nozzle. This work is accomplished at a very low rate—less than two cents per cubic yard. This cost includes power, labour, pump and hose. When the face of the rock has been laid bare, actual quarrying is carried on by drilling and blasting. Early in 1909 there were at work thirty drills operated by compressed air. Twenty-four of these drills were of the 3⅝-inch size; the remainder were 2½-inch tripod drills. The air was brought to the region by use of a 6-inch main. The working pressure was about 100 pounds per square inch. The holes were drilled at intervals of about 10 feet, and were loaded at the bottom and at the middle. Small charges of 60 per cent. dynamite were employed because it was not desired to throw the rock, but only to shatter it. At that time the average day's work per drill was 34½ feet, but it was expected to increase this rate. The blasted rock was loaded onto cars by means of steam shovels. These had their dipper capacity limited to about 1¾ cubic yards, the purpose being to avoid loading pieces too large for the crusher. The dippers were made of extra heavy plate, and the teeth were of manganese steel. The crushing plant at first consisted of one No. 9 McCully crusher, furnished by the Power & Mining Machinery Company, and three No. 6 McCully crushers. This equipment was later on duplicated. It was found, however, that while the plant was competent to crush the amount of stone needed, it would be advantageous to use a preliminary crusher capable of handling any rock brought to it. It is said that on some days it was found necessary to fire upwards of 1,200 shots and consume half a ton or more of dynamite in breaking up pieces of rock too large for the No. 9 crushers. A huge McCully crusher has accordingly been installed. This apparatus has a hopper diameter of 20 feet.

Everywhere on the canal American contracting machinery is in evidence. At one place it will be the Hayward (the Hayward Company, New York) orange peel bucket operated from a dredge. At another, the same type of excavator will be cutting through the toe of an old dam for the purpose of providing an outlet for a natural

stream. The same piece of apparatus will again be seen in the city of Colon patiently digging a passageway for the sewage. If considerable quantities of sand are to be handled, reliance will not be placed upon swarms of men, but upon mechanical devices. Prominent among the apparatus used for this purpose is the crane of the Cleveland Crane & Engineering Company, of Wycliffe, Ohio. And so it is everywhere. The great jobs of moving material in bulk are performed by machines. Men are used on the canal. But they are used for minor details.

PASSING THE LOCKS

A cardinal regulation governing the operation of the canal will be the requirement that no ship shall pass through a lock under its own power. In this way a desirable minimum of accidents, both to ship and locks, will be secured. When a ship has gotten well into the forebay of a lock, or system of locks, she will come to a full stop and be taken in charge by four electric locomotives. A taut hawser will connect each quarter of the ship with one of the locomotives, so that there will be two ahead and two astern. These locomotives will operate on tracks laid on the walk of the locks. The two forward will tow; the two to the rear will maintain the after part of the ship in correct position. There will be two tracks on either side of a lock chamber—one for towing, one for returning. But the return track laid on the centre wall will be the same for both flights of locks. At the Gatun Locks and at Miraflores Locks, where there is more than a single lift, the tracks will be at more than one level. Thus at Gatun Locks there will be three levels at vertical intervals of, perhaps, 30 feet. Between the levels of the lowest locks and of those next above the upper tracks will be 29 feet 7 inches above the lower ones. It seemed desirable to accomplish this rise in the shortest horizontal distance possible. Accordingly, the two vertical curves and the included incline occupy a total of only 106½ horizontal feet. The maximum grade is 1 on 2.

It is expected that forty electric locomotives will be required to equip the three lock locations. One will first be tested, when minor changes will, no doubt, be found desirable. The system of towing is the invention of Mr. Edward Schildhauer, a member of the engineering staff employed by the Canal Commission. A patent has been applied for, but the Government will have the use of the system without charge. It may well be imagined that a night towage will be a most interesting sight. The moving headlights of the four locomotives, together with the lights on shipboard, will make up a novel system of illumination. It is expected that the rate of towing will be about two miles per hour. The only switches will be at the ends of the railways.

The change of level will be made by the forward locomotives during the period when the ship is being raised or lowered in the lock chamber. They will exert no tractive effort at this time. The towing tracks and the inclines are provided with racks laid half way between the rails. The level portions of the return tracks have no racks. When towing or changing levels a locomotive will operate by the aid of the rack. At other times friction will be relied on. The teeth of the racks are 3.13 inches apart from centre to centre. The racks themselves will be of cast steel, and the form will be such as to preclude the passage of lubricant to the concrete of the lock wall, and such as not to retain water in the interstices. The latter provision is made against mosquitoes. Having towed a ship all the way through the locks and out into the forebay, the locomotives will reel up their cables and return, or will perform another towing operation, this time in the opposite direction.

The locomotives will not all be of

one size, because of the great variation in tractive service. On some occasions it may, perhaps, be necessary to use more than four. One of these locomotives consists of three sections—a front and a rear tractor and an intermediate windlass. Each tractor has a rigid wheel base 5 feet 6 inches long and 5 feet wide. The two tractors are duplicates the one of the other. There is to be for each a tractor motor capable of exerting a torque of 840 pounds at a radius of 1 foot with the spindle rotating at 470 rotations per minute. It will be capable of an overload of 75 per cent. for one minute. A train of gears provides for the considerable speed reduction required to transform the pitch line speed of the motor pinion down to a pitch line speed of the rack pinion amounting to only 2,110 feet per minute. Within this gear train are no clutches. As there is no means of disconnecting the train, the rack pinion will never be in motion when the motor is quiet. If the current should, for any cause, be shut off from the motor, a solenoid brake operates at once to bring the tractor to a stop. Both tractors can be operated as a single locomotive from the cab of either. The motors of both tractors will be worked in parallel. Since weight is not needed in order to secure the tractive effort necessary, the locomotives will be of fairly light construction, the weight being estimated at 70,000 pounds. The windlass will be hung between the two tractors of a locomotive; it will have no wheeled support of its own. There will be a winding drum of 18 inches diameter. By means of a friction clutch it will be protected from a pulling strain of more than 25,000 pounds. When the line is operated against a load resistance the speed will be about 10 feet per minute; a second speed of 200 feet per minute is provided for coiling the line when unloaded. Separate electric motors provide power for the two operations. The power of the load moving motor will be such that a torque of 120 pounds will be exerted at a radius of 1 foot with the rotational speed of 630 rotations per minute. The other motor will, of course, be much less powerful. From the ship to the drum of the windlass the line will be 215 feet. A 4-foot loop will be at the ship end. At the point where the line is about to pass in through the roof of the windlass housing it will encounter a sheave. This last is arranged in a turret, which is free to rotate horizontally. In this way provision is made to have the line load directly on the guiding sheave at all times. The towing line will have a hempen central core, around which six strands of thirty-seven wires each will be twisted. The wires are to be of plow steel, and are required to have a tensile strength of not less than 225,000 pounds per square inch. The hawser itself must have an ultimate strength of 70,000 pounds.

Because of the great depth and great width of the waterway through the locks, the question of the form and construction of the lock gates has not been a very simple one. Two types of gate were considered: the arched type of gate and the mitering type. The decision as between the two turned largely upon the amount of space required by them when open. The arched form requires, it seems, a large recess in the side wall. If it had been adopted the central wall between adjacent lock chambers would have been thinned, or would have necessitated a thickening of the wall throughout nearly the whole of its length. Neither alternative seemed advisable, so the mitering type was selected. They will be of steel and in the form of girders. The weight will be greater than would have been necessary with the arched type, but this consideration is offset by the increased cost of curved work.

Altogether, forty-six gates of two leaves each will be required. Spare parts for an additional gate of the larger size are to be kept on hand.

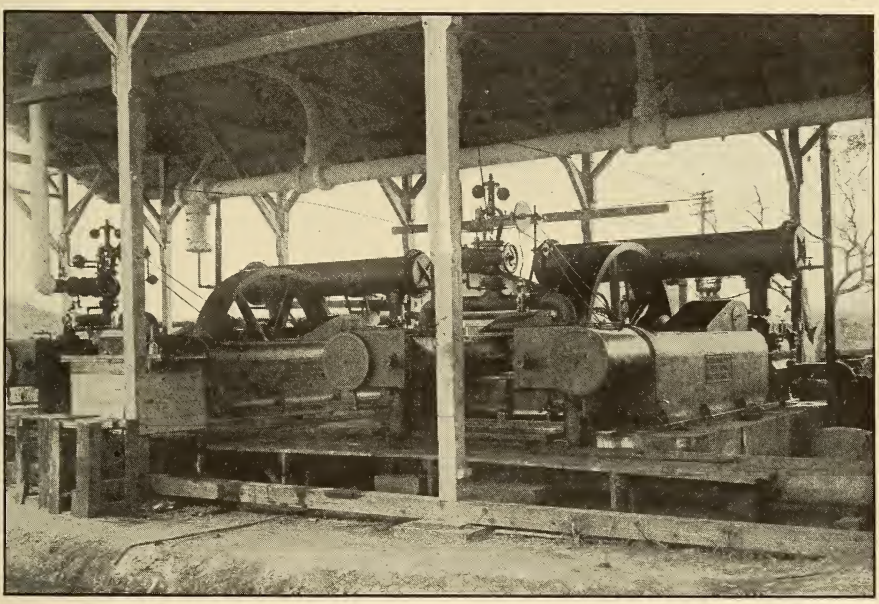
The heights of these gates range from 47⅓ to 82 feet. One leaf of the largest size will weigh 1,483,700 pounds. The contract for the gates was awarded to the McClintic-Marshall Construction Company, Pittsburg, Pa., as this concern was the lowest bidder. The bid was $5,274,474.82 for the whole work, including, apparently, erection. It has been calculated that if the gate leaves were piled one upon another, end to end, a tower more than 1¼ miles high would result. The fixed parts which are built into the concrete total a very considerable amount of metal work. The contract was awarded the United Engineering & Foundry Company, Pittsburg, Pa., the amount involved being $528,000. Included in this contract are 3,364,000 pounds of structural steel, 9,247,000 pounds of steel castings, 743,000 pounds of nickel-steel plates and 406,000 pounds of cast iron, besides 196,000 pounds of miscellaneous parts.

A great deal of machinery will be concerned in the operation of the canal once it is thrown open to traffic. A part of this machinery has already been referred to or described in some detail. As an example of other apparatus required may be mentioned the mechanism necessary to the opening and closing of the forty-six lock gates. These will have to be moved from a state of absolute rest. There will have to be created a flow of water from in front to the rear of each gate leaf. The opening through which this current will have to flow will be at a minimum at either position of rest. The effort will, therefore, have to be greatest at the beginning and at the end of the leaf movement. It is expected that the foregoing conditions will be met by machinery capable of the heavy duty involved in moving the leaves at a reasonable rate of speed through the intermediate position and more slowly at the terminal positions. The many valves controlling the flow of water into and out of the lock chambers will also require special machinery.

It will be readily understood that some limit had to be set to the strength of the lock gates and to the operating ability of the connected machinery. They are, no doubt, designed to cover in a very complete way the normal requirements. But this provision has to be made for the following contingency: Through some accident to lock gates at Pedro Miguel or Gatun a current of water may begin to flow from Gatun Lake to a lower level. This might become swift enough to render unsuccessful all efforts to close mitering gates in the lock concerned. It has been decided to provide for this contingency by the construction of movable dams. These devices are to guard the two outlets from the 85-foot level, also the outlet from Miraflores Lake. They are to consist of swing bridges. These are trussed both horizontally and vertically. Under ordinary conditions they will rest in waiting position on the side walls of the locks. When needed, they will be swung in a horizontal plane to a position transverse to the line of the canal. Wicket girders and rolling gates, together with the bracing between these, complete the main feature of the dams. To bring these apparatus into full service requires operating machinery. And so the mechanical requirements of the canal are still further increased.

In fact, the whole waterway will really be a huge and complex piece of mechanism. Not only have power-driven mechanical appliances been, from a practical point of view, necessary elements in the digging of the canal and in the construction of the colossal structure scattered along its length, but power-driven apparatus will be essential to its operation. The civil engineer is not only not independent of the mechanical engineer, but he must have his full and hearty co-operation in order that he himself may carry out with boldness and success his own great plans for the benefit of the human race. The nine-

teenth century saw the dawning of the day in which civil engineering had its possibilities enormously increased by mechanical engineering. But it is the twentieth century which sees the day in its full glory. The Panama Canal will be a machine-dug waterway; it will be a machine-built construction; it will be a machine-operated mechanism. It is by far the greatest example of the new order of things. Because of the great fact of the Panama excavation, it may confidently be predicted that henceforth no civil engineer will ever undertake any enormous piece of excavation—whether wet or dry—in dependence upon hand labour. He will dig with power-driven mechanical appliances. Because of the great constructions at Panama—the breakwater construction, the enormous locks, the gigantic dam at Gatun—the civil engineer of the future can hardly undertake any great constructive operations without putting his reliance upon power-driven mechanical means of getting his materials of construction to the point of actual use. With the Panama Canal as an undeniable witness of the possibility of the power-driven mechanical appliance becoming well-nigh a controlling factor, it will hardly be possible for the civil engineer to go into any great enterprise in the future—whether that enterprise involves the solving of problems precisely similar to those encountered at Panama or not—it will hardly be possible for him to undertake any great work whatsoever without investigating the possibilities of combining power generators and mechanical apparatus. The Panama Canal may be confidently expected to be a great stimulator of what is really becoming a new science or art—the science or art of applying mechanical engineering to problems encountered in civil engineering. This new department is still in its infancy, although it is quite a vigorous infant. Great and unsolved problems are ahead. But great success in one line of activity may be counted upon often



TWO IMPERIAL TYPE AIR COMPRESSORS, MADE BY THE INGERSOLL-RAND DRILL CO., NEW YORK, IN POWER HOUSE AT EMPIRE, CANAL ZONE, PANAMA

to reinvigorate those working in another line. So, some of these problems will undoubtedly be solved largely because of the encouragement supplied by such great successes as the Panama Canal. As an example of an unsolved problem may be cited the excavation incidental to the sinking of vertical shafts by compressed air. This excavation is now being done by hand labour. The sand hog must be present at the point of excavation. This puts a very serious limitation upon a most excellent method for the exclusion of water. Forty-five or forty-seven pounds of pressure per square inch is about all that human beings can safely endure—if, in fact, these pressures are really safe. But 47 pounds per square inch corresponds to a hydrostatic head of only a little over 100 feet. If we were to penetrate by the compressed air method to greater depths, it would seem necessary to provide a mechanical means of carrying on the excavation in order not to require the presence of the human excavator.

SALT AND FRESH WATER

A most curious question has arisen in connection with the locks at Gatun and Miraflores, which open on the sea-level sections. When these locks are filled to the next higher level the additional water comes from Gatun Lake or Miraflores Lake. That is to say, the added water is fresh. A fair statement would be that all the water in these locks when full is fresh from the sea level up. Suppose now that a ship has entered one of these locks with the purpose of descending to the sea and that the gate to the rear has been closed. Suppose, further, that communication with the sea level section of the canal by means of the great 18-foot discharge culvert and all subsidiary culverts has been opened up. Because of the hydrostatic head supplied by the fresh water in the lock chamber a rapid discharge will begin. But when will it cease? Undoubtedly it will cease when the hydrostatic heads outside and inside the lock chamber become, in point of pressure, equal. But since the water inside the chamber is much less salt than outside, and, consequently, possesses a lower specific gravity, the equalization of pressure will occur when the water level inside is higher than that outside. In other words, the flow will cease before the levels are equalized. A difficulty would then arise, it is conceived, in connection with the opening of the gates—the pressure being different on the two sides. It is held that by depressing the discharge culvert to a possible point the difference in pressure can be reduced to a manageable amount, or even to zero. The presence of tidal effects must also be taken into account. The result of an investigation into the matter has been the recommendation to place the whole faces of the discharge culverts in a horizontal plane and to locate them at 21 feet below the sea level at Gatun and at 25 feet below at Miraflores.

WHEN WILL THE CANAL BE DONE?

The official date for the completion of the canal seems still to be January 1, 1915. It is most probable, however, that the work will be finished considerably ahead of that day. It is reliably reported that Gatun Locks will be finished by June, 1912; the Pedro Miguel Locks in August of the same year, and Miraflores Locks in the following October. This report probably takes account only of the concrete construction and has no reference to fittings, accessories and operating machinery. The work necessary to the completion of the equipment, however, is already well advanced, and it is scarcely to be regarded as at all impossible that it will be brought to a point of final consummation not long after October, 1912. It should not surprise anyone if the canal should be ready for its opening day in the late summer or fall of 1913.

SEARCHLIGHTS

By J. M. Heslop

In view of the fact that the possession of a suitable searchlight might have gone far toward indicating the presence of dangerous ice long before the ill-fated *Titanic* approached within danger distance of the iceburg, the present discussion of marine searchlights will prove both timely and interesting. The lecture, of which this article is an abstract, was delivered before the Sunderland Technical College Engineering Society, and the fact that it was prepared and delivered before the disaster to the *Titanic* renders it entirely free from any special inspiration due to the facts brought out at the later date.—The Editor.

IT was during the year 1862, in the American Civil War, that Lieutenant Cushing, by means of an explosive charge lashed to a spar projecting over the bows of a fast steam launch, blew up the Confederate ironclad *Albemarle*.

This was the first time that the torpedo had been practically used in belligerent operations, and it marked the opening of a new epoch in naval warfare. It also made apparent the need for some means of detecting these small boats before they had time to get near enough to place the charge and fire it.

The first answer to this necessity was a piece of apparatus consisting of an electric arc lamp and a Fresnel lens, enclosed in a metal case, and mounted in such a way as to be capable of rotation in two planes, thus ensuring the illumination of any spot.

About ten years later (in 1871, to be precise) Mr. Robert Whitehead invented the torpedo which bears his name. This torpedo, as is well known, is discharged from a boat when some distance away from the object of its attack.

Here arose a fresh complication, for although the arc lamp and the Fresnel lens answered admirably for the short ranges necessitated by the use of the spar torpedo, it was soon found that a boat could lie outside the zone of light and discharge a Whitehead torpedo without being seen.

Attempts were, therefore, made to obtain a more powerful beam of light; and these efforts culminated in the Fresnel lens being superseded by a glass mirror coated with silver.

This remains the essential form of the modern searchlight. Needless to say, numerous improvements in the details have been effected, principally in the matter of the lamps, the mirrors and the control.

Although introduced primarily to meet naval requirements, the searchlight is not by any means unknown in the mercantile marine. At least one is provided for in the equipment of every up-to-date liner, and no ship is allowed to pass through the Suez Canal without one of a particular type (if the vessel has not one of her own she must borrow one from the Canal Authorities). Again, no steam yacht of any pretensions whatever would be considered to be complete if there were not a searchlight in its electrical equipment. Those steamers also which have occasion to navigate the large rivers of South America and of the continent of Africa and the great inland lakes of North America find a searchlight invaluable.

It is well known that the full moon gives sufficient light to enable fairly distant objects to be seen with distinctness; and it has been found that the illumination given is enough to make it an easy matter to distinguish a small object, such as a torpedo boat, with absolute certainty as to its na-

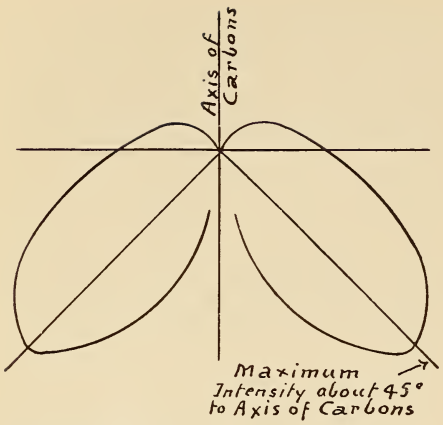


FIG. 1.—CURVE OF LIGHT DISTRIBUTION OF AN OPEN ARC

ture when it is about 1,000 yards away.

The obvious question, therefore, is can such an illumination be obtained with any artificial source of light?

Before this can be satisfactorily answered it is necessary to know the exact value of the illumination at the surface of the earth due to the moon. This has been determined, and is given as 0.028 candle feet (maximum)—i. e., this is the highest observed value. A good mean value is about 0.020 candle feet for average full moon.

If an illumination of this value is desired at a distance of a thousand yards the necessary source of light must be of an intensity of 0.020 $(3{,}000)^2$, or 180,000 candle-power.

The most powerful source of light in general use at the present time is an electric arc, taking a current of 150 amperes. There are more powerful lamps which take as far as 200 amperes, and even 250 amperes, but these are not in general use.

The 150-ampere lamp gives about 60,000 candle-power maximum, but, as will be seen from Fig. 1, this maximum candle-power is obtained at an angle of about 45 degrees to the axis of the carbons; therefore, if it is desired to use these rays of maximum intensity to illuminate a spot 1,000 yards away, it is quite obvious that the lamp would have to be raised to a height of 1,000 yards. Such an elevation as this is out of the question in almost any case, but more especially in the case of a ship. About 60 feet is the utmost elevation that can be reckoned on in such a case, and this means that only about one-sixth of the maximum candle-power is available at the prescribed distance. Consequently, the illumination obtainable will only be about 0.0011 candle foot.

This is not nearly sufficient. It will be noted, however, that this illumination is obtained by means of an arc lamp which is merely suspended in space, as it were, "with no visible means of support" and no mirrors whatever. In such a system the light is thrown out in the form of a sphere, and as a result a great deal is wasted; also, in the immediate neighbourhood of the lamp the illumination is a maximum, and at a distance it is a minimum, which obviously is contrary to the desirable state of affairs. If, therefore, matters could be so arranged that some of the superfluous light in the neighbourhood of the lamp could be used to reinforce that at the more distant points, it would be more satisfactory. Suppose, therefore, that a conical mirror is introduced beneath this suspended lamp; the light would be thrown out in a horizontal direction, and, by a suitable choice of mirrors, could be made to cover a circle of any desired radius. A conical mirror of this type can, however, reflect usefully only a comparatively small proportion of the light thrown on it; for, as will be seen in Fig. 2, a large number of the rays are reflected above the horizon, and so are wasted. A larger amount of light could be reflected if the mirror used were such as would be obtained by the revolution of one branch of the hyperbola about the axis of the carbons; and, if instead of a hyperbola a parabola were rotated, the amount of light reflected would probably be greater still. This

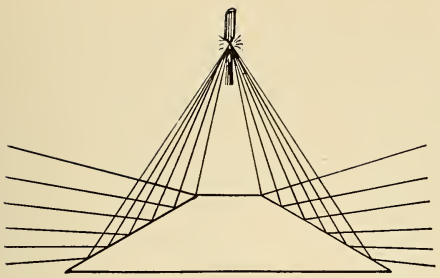


FIG. 2.—DISTRIBUTOR OF LIGHT WITH CONICAL MIRROR

is all very well as far as the theory of the systems is concerned, but in practice it is found that with these arrangements the mirrors required would be of such a size as to render their manufacture almost an impossibility.

Some other more practicable means must, therefore, be adopted; for instance, if, instead of illuminating a circle, the light were condensed into a slightly conical beam and mounted so as to be capable of rotation, it would be feasible to examine the whole of the required area with a very powerful beam. This is what is actually done, and it is accomplished by using a mirror of the form traced out by rotating a parabola about its own axis.

Thus much for what might be called the "evolution" of the searchlight.

Although glass is a material which will take a very good polish, and is for that reason always now used for searchlight mirrors, it was a long time before it was possible to manufacture glass parabolic mirrors with any degree of accuracy. Hence, for some time mirrors of this form were made of metal, the particular metal being an alloy known as speculum metal. Whenever glass mirrors were used they were made spherical in form; this practice was, however, found to be undesirable on account of the great amount of spherical aberration. About the year 1876 Mangin found that if a spherical mirror, instead of being of uniform thickness throughout, were made in the form of a concavo-convex lens, thus making it thicker at the edges than in the middle, there was practically no spherical aberration. This was a great advance, and the "Mangin" mirror came very much to the fore. Ten years later, however, Schuckert was successful in his endeavours to make a parabolic mirror out of one piece of glass, and after that the glass parabolic mirror became *the* mirror, in practice as well as in theory.

The earliest form of searchlight, as was said above, consisted of an arc lamp with the carbons vertical, or, to be more correct, inclined, enclosed in a case fitted with a Fresnel lens, and so mounted as to be capable of rotation in two planes. The great drawback to this system was that if the source of light moved with respect to the lens, the direction of one part of the beam was altered in one direction and another part of the

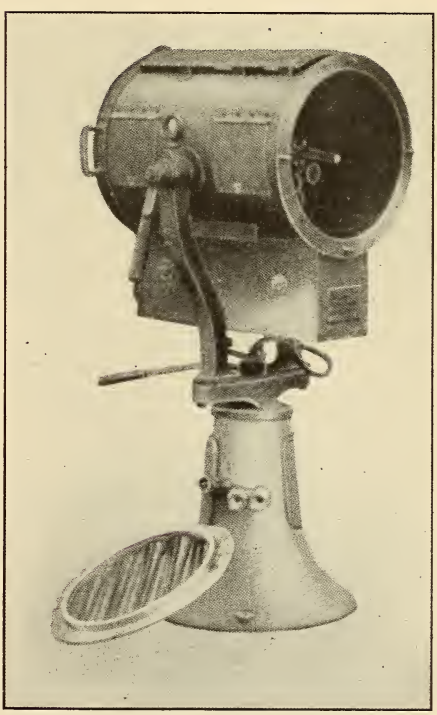


FIG. 3.—A 12-INCH YACHT TYPE PROJECTOR. MESSRS. CLARKE, CHAPMAN & CO., LTD.

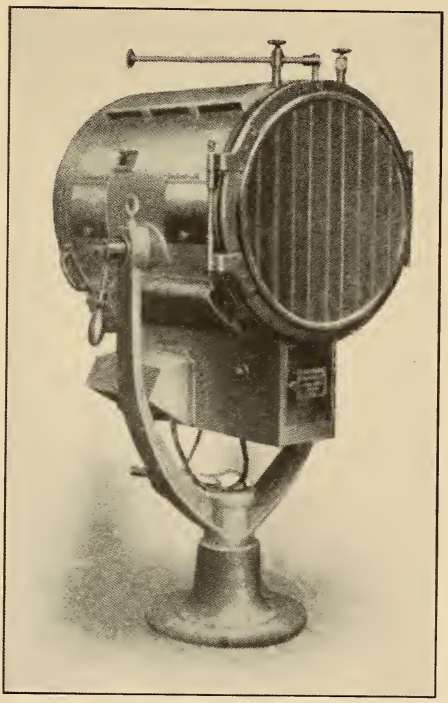


FIG. 4.—GENERAL APPEARANCE OF A SEARCHLIGHT HOOD

beam was moved in the opposite way, thus splitting up the beam and impairing its intensity. Thus, unless the arc is constantly kept in the same position, the intensity of the light will continually be varying and causing no end of trouble.

The modern searchlight, or projector, consists essentially of the following three parts:

1. The projector body, with glass parabolic mirror, horizontal lamp, lamp adjusting and carbon adjusting gear, and front glass;

2. Turntable, with arms for carrying the trunnions which support the body, and hand gear for training and slewing;

3. Base, sometimes containing the lamp steadying resistance, or, in the case of a motor-controlled projector, the motors for the slewing and training motions.

The body, or hood, as it is termed, is made of sheet steel, generally about 3/32 inch thick. At each end it is strengthened by an angle iron rim. To the rear ring is attached the back cover, also of sheet steel, and in this cover, carefully mounted on springs, is the mirror.

The ring at the front of the hood supports a gunmetal ring, which carries the front glass. This is a circular sheet of plate-glass about ¼-inch thick, and is a means of protecting the lamp; it can be seen in Fig. 3, which shows one of Messrs. Clarke-Chapman's 12-inch yacht type projectors. The bottom part of the hood is cut away to allow the introduction of the lamp arms, and round the sides of the slot thus formed the box is riveted, the function of the said box being to carry the lamp itself. It is common knowledge that an arc lamp, when burning, develops a great amount of heat; so to avoid injurious overheating of the hood, and, above all, of the mirror, a number of ventilating slits are cut in the hood, and by this means the hot air escapes at the top and is replaced by cool air from beneath. These openings are fitted with copper baffle plates or cowls, which fulfill the double purpose of keeping out the rain and of keeping in the light. The general appearance of the hood can be seen in Fig. 4, which is of a light type projector, by Messrs. Clarke, Chapman & Co. In the side of the hood on either side of the trunnions can be seen openings covered by small copper doors. These permit of easy access to the interior of the hood for such purposes as cleaning, fitting new carbons, etc. There is also provided in the side of the hood a small observation hole fitted with a darkened glass, or, more frequently, a piece of coloured mica, for the glass was found almost invariably to crack with the heat. The object of this "glass" is to permit of the examination of the arc while burning.

To provide for training the searchlight the hood is mounted on two trunnions. These trunnions are screwed to the hood in such a way that it is exactly balanced on them.

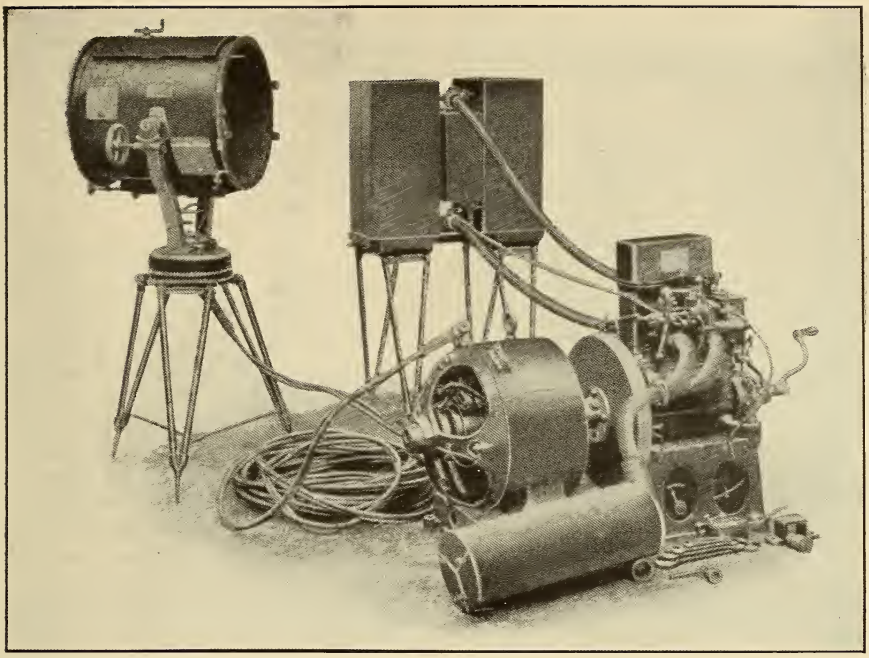


FIG. 5.—APPARATUS USED IN TRAINING A SEARCHLIGHT

They are carried in bearings fitted in the tops of the side arms.

The side arms just mentioned are made in a variety of patterns. In some cases they are of cast steel of channel section; in other cases, they are formed of a frame of steel rods, or, if lightness is essential, instead of rods steel tubes are used; as, for example, in a projector for field use.

The trunnions provide the mounting necessary for the training motion, but gearing is nearly always fitted to enable the motion to be controlled. This control is effected in a variety of ways. Thus, a worm wheel may be attached to one trunnion, and a worm—generally single-threaded—gears with this wheel, and is carried to a gunmetal bracket bolted to the side arm. This method is shown in Fig. 5. Another method consists in screwing or riveting a sector-shaped gunmetal rack to some such part as the lamp box, and a small gunmetal pinion gearing with the rack is carried on a spindle passing through a bushed hole in one of the side arms. See Fig. 6, which is a 24-inch projector of Messrs. Siemens manufacture. There is a third method, adopted, as a rule, in small projectors, in which training is effected by means of two handles at the back of the hood, the projector being locked in the required position by the aid of a lock nut on one of

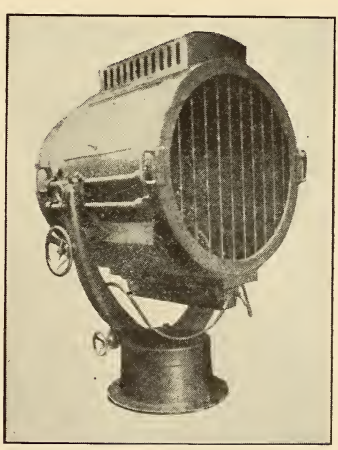


FIG. 6.—A SIEMENS 24-INCH PROJECTOR

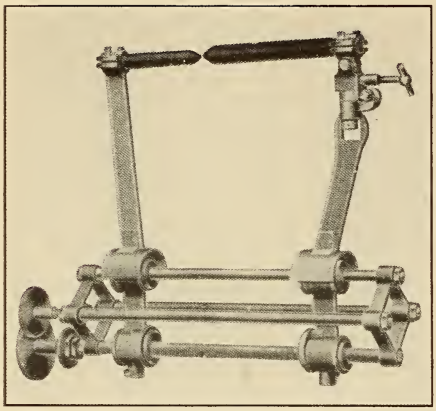


FIG. 7.—A TYPICAL HAND-FED LAMP

the trunnions. This arrangement is also very often fitted to supplement one of the other methods. It then acts as a sort of "coarse adjustment," the "fine adjustment" being provided by the worm and worm wheel or the rack and pinion, as the case may be. Of course, provision is made for throwing the "fine adjustment" out of gear while using the "coarse."

The side arms mentioned before are carried on a turntable, which can be rotated about a vertical axis, thus providing for the "slewing" of the projector. In high-grade machines this turntable, which is generally of cast brass or gunmetal, is carried on ball bearings, or sometimes on rollers. In the case of the ball bearing mount there are very often two sets of balls, one set for supporting and another set for centering; but as often as not the centering is effected by means of a central pin. In the case of the smaller machines the turntable is often reduced to the rudimentary form of a boss, to which the side arms are attached, either by bolting or by being cast in one with the boss. Fig. 4 explains this method of construction.

Beneath and supporting the turntable is the base. This also has a variety of forms. It is sometimes of cast iron and sometimes of sheet steel; it is sometimes cylindrical and sometimes conical; it is sometimes in the form of a rectangular prism and sometimes in the form of a rectangular pyramid; according to the requirements of the case, so is the shape and form of the base adopted.

Having gone thus far over the external features of the searchlight, let us now turn our attention inwards, so to speak.

The first thing to be considered is, perhaps, the lamp. Of this there are two varieties, viz.: the hand and the automatic. The hand lamp consists essentially of the arms for the carbons and a framework to support them. This frame is made in different ways; one form consists of four steel rods screwed into two end-plates. Another type consists of an aluminum tray. But whichever the form, it carries two screws, one right and the other left-handed; these two screw-threads are both cut on the same rod, and thus by turning the rod the carbons can be approached or drawn apart. It will, of course, be understood that the screwed rod passes through the lamp arms. (Fig. 7 shows a typical hand-fed lamp.)

In the automatic lamp the actions of approaching and drawing apart the carbons are carried out, as the name implies, automatically, through

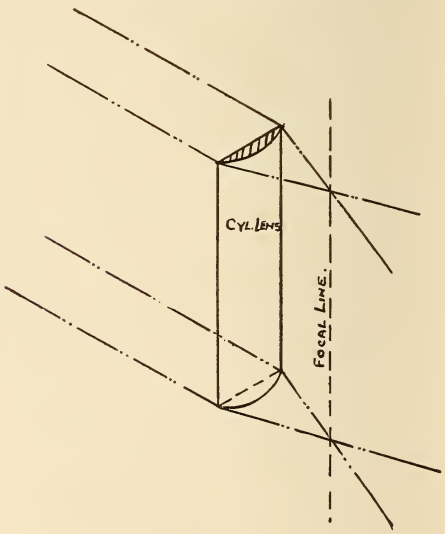


FIG. 8.—EFFECT OF A CYLINDRICAL LENS ON A BEAM OF LIGHT

the medium of a small motor. The action is as follows: If the carbons are not in contact when current is switched on there is only one path open to it, and that is through the shunt coil of the feeding motor. Being thus supplied at the full voltage, the motor feeds the carbons together rapidly.

When the carbons eventually come into contact there is a path open to the current through the carbons, and also through a coil which is connected in series with the carbons—viz.: the arc striking coil. The current thus passing through this coil energizes it and draws the carbons apart. This cuts down the current in the shunt coil, and, consequently, stops the feeding of the carbons. The automatic lamp can also be used by hand. For this purpose a small lever is mounted in a conspicuous position on one end of the lamp box; two small index plates are also attached, one marked "Hand" and the other marked "Automatic." When the point of the lever is placed opposite the latter of these the sequence of actions is as just described, but when turned to the other position the effect is to cut out of circuit the feeding motor and its attendant gearing. Then by the aid of a hand wheel the carbons can be moved at will. The next important item inside the projector is the mirror.

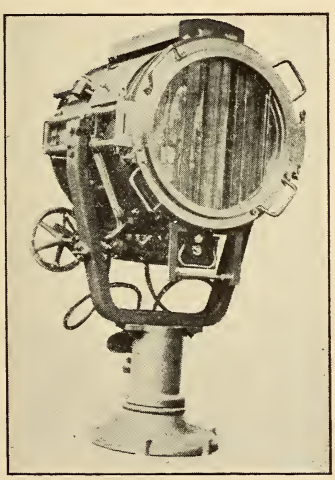


FIG. 9.—A 16-INCH PROJECTOR. MESSRS. CROMPTON & CO., LTD.

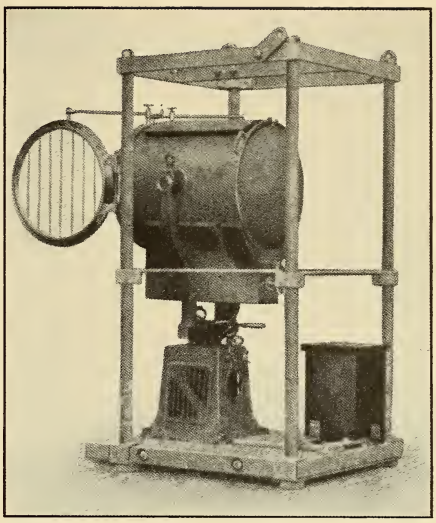


FIG. 10.—GENERAL ARRANGEMENT OF OUTFIT NECESSARY FOR PASSAGE OF THE SUEZ CANAL

This, as was pointed out herein, is nearly always of the parabolic type, glass being the material of construction. The silvering is effected in a variety of ways, possibly the most generally used being the electrolytic method, in which silver is electrically deposited on the convex side of the mirror. These mirrors answer admirably, about the only trouble being to keep the silvering from burning off. There has recently been placed on the market a modification, or, rather, an elaboration, of this type of mirror, in which not silver but gold is deposited. These mirrors are said to possess numerous advantages over the ordinary silvered mirror, such as softer and more even illumination, greater penetration in foggy weather, etc. Another great advantage claimed for them is that they do not deteriorate so rapidly in damp and tropical climates as do silvered mirrors.

There is, perhaps, no property of the searchlight more important than its capability of throwing a powerful and concentrated beam of light in any particular direction. But the concentrated beam is not always the

most desirable. There are times when a beam of light well spread out over a large area would be of very much more use. Take, for instance, the case of a steamer trying to pick up a buoy. It is not very difficult to see that with a concentrated beam having quite a small amount of dispersion it would, in most cases, take more time, in spite of the more powerful light, than it would with a less powerful light spread out over a larger area. Having once "spotted" the buoy, the concentrated beam could with advantage be used to follow it up. To provide this dispersed beam a diverging lens or "disperser" is used. This consists of a number of cylindrical lenses mounted in a metal ring. The action of the disperser is shown in Fig. 8, which shows the effect on the path of a ray, or rather a beam, of light, of a cylindrical lens. The direction of the ray is not interfered with in the direction of the axis of the lens, but in the direction at right angles to the axis the ray is refracted or bent in precisely the same manner as in the case of an ordinary spherical lens. The result is that, instead of a cone of light having a focal point, there is a wedge of light with a focal line. The diverging lens is hinged on to the front of the projector, and can be distinctly seen in Figs. 4, 6 and 9, this last being a 16-inch projector by Messrs. Crompton & Co., Ltd.

There is no space to deal here with such items as the detailed testing of searchlights, with respect to the intensity of the reflected beam, radius of action, etc., nor with portable power sources for field use, nor even with the various applications of projectors. One particular application might here be described as a fitting conclusion—viz.: the Suez Canal type. The Suez Canal regulations stipulate that the projector shall be capable of giving the required light under two different conditions. In the first case, when no vessel is approaching a concentrated beam of light uninterruptedly illuminating both banks of the canal is required. On the approach of a vessel being noted, though, the concentrated beam in order that the navigation of the approaching ship may not be interfered with, must be split up in the following manner: the angle of divergence of the beam must remain unaltered—that is, the width must be the same as that of the concentrated beam, but there must be a dark interval of 5 degrees extent in the middle of the beam. This dark interval is, of course, to prevent those in charge of the approaching vessel being temporarily blinded, with results which can be imagined better than described. The complete outfit for the passage of the Suez Canal is:

1. A projector with lamp and mirror complete. (Usually 20-inch mirror and hand lamp.)

2. Two diverging lenses, one for the concentrated and one for the divided beam. These are hinged onto the front of the projector.

3. A cage to carry the projector, and arranged to be slung over the bows of the ship.

4. The necessary lamp steadying resistance.

5. An arc lamp (3,000 candlepower) for use at the masthead when the ship is at anchor.

The general arrangement of such an outfit can be gathered from Fig. 10.

For Figs. 3, 4, 5, 7 and 10 the writer is indebted to Messrs. Clarke, Chapman & Co., Ltd., while for Fig. 6 he wishes to thank Messrs. Siemens, and Messrs. Crompton & Co. for Fig. 9.

THE COAL STRIKE: ITS CAUSES AND CONSEQUENCES

By T. Good

AN important turning point in the industrial career of Great Britain has been reached. The national coal strike solves some old problems, creates some new ones, and opens out a vast avenue of possibilities. It has suddenly brought into existence a new set of conditions it would be folly to underrate. It will have far-reaching effects upon trade unionism and political movements, upon the minds and policies of employers and workmen, upon the relationship between capital and labour, between industry and the State, and also upon many problems of science and engineering. Much will depend upon how we adapt ourselves to the new circumstances. It will be well, therefore, to get down immediately to the bed-rock facts. We must recall the developments that have culminated in the crisis and the enactment of the Minimum Wage law. We must know the why and the wherefore, or we cannot shape our future course to the best advantage. Misconception led to the strike. Misconception prolonged the strike. Misconception brought the strike to a false termination. Misconception must not be allowed to work further mischief. The end of the strike has not brought the end of the trouble. We must not imagine that we have done with the miners' wage question. Instead of trying to forget the sorry business we had better take a much deeper interest in it.

The first point that should be made clear is why the miners indulged in a national strike. There is much misconception even on this elementary question. It is said that the miners and their leaders were practically unanimous, that the men displayed a marvelous solidarity, and that nothing less than the concession of the minimum wage, either voluntarily by the owners or under legislative compulsion, would serve to end the strike. This is an absolutely mistaken view. Between 200,000 and 300,000 of the men would neither be led nor driven into the Miners' Federation, and another 200,000 members of the organization could be neither coaxed nor cozened to vote for a strike on the minimum wage; 115,000 union men dared to vote against the strike and in defiance of their leaders' advice. Out of more than 1,000,000 mine workers only 445,000 yielded to the agitation and voted in favour of the strike policy, and the bulk of this minority voted under complete misapprehension. The leaders emphatically declared that, even if the bare threat of a national strike did not induce the owners to yield, a very few days of an actual national strike would compel surrender. They assured the men that they would win a huge and swift victory by simply taking a short holiday. Yet, in spite of all the promises and assurances, less than half a million were duped. The other half million joined in the strike, some under terrorism, but most of them in a holiday spirit. Thus the so-called national strike was declared upon a minority vote, and entered upon with little real enthusiasm, save by those who had been misled. In non-union men, in union men who did not vote for the strike, and in union men who dared to vote against this purely agitators' movement, we had actually more than half the mine workers opposed to the strike. It is a pity that fact was overlooked by the Government. If there had been full recognition in high quarters of the artificial character of the strike

the whole of the men could have been got back to work within a fortnight. In less than a couple of weeks large numbers of those who voted for the strike had discovered how they had been deceived, and if a secret ballot vote had then been taken upon the owners' amended terms—a secret vote of all the men, union and non-union—there would have been a large majority for resuming work upon those terms, and no fantastic legislation would have been necessary. The situation was misjudged. It was forgotten that it was a million men, and not a dozen leaders, who were on strike.

Now, while the majority opposed the strike policy, or had no enthusiasm for it, we had the spectacle of a minority of the men engaged in the industry bringing the whole trade to a standstill because they constituted a majority of a part—a majority of the unionists—and because they had been misled. Not only were these men led to believe that the strike could be nothing worse than a very short holiday, on strike pay, and that even if the owners did not immediately yield to the Federation demands the Government would soon nationalize the mines and pay high wages, but throughout the entire agitation, and upon the very principle of the minimum wage, the men were shockingly and shamefully misled.

In the first place, the miners were led to believe that almost fabulous profits were wrung out of their labour, that the coal owners were a greedy set, and that much higher wages could and ought to be paid. Balance sheets of a few favoured companies in their most favourable years were quoted to the men as though they were typical. Facts and figures were distorted, and even glaring falsehoods were spread among the miners. As examples of the stories by which passions were roused, I may mention that in a pamphlet circulated among the miners it was declared that coal owners' profits amounted to £27,000,000 a year; in another pamphlet it was said that every miner's wage could be increased by 5*s.* per week without raising the price of coal and yet leave a fair margin of profit. In a well-known labour journal it was asserted that profits exceed £16,000,000 a year, besides the royalties; it was even stated in cold print that profits and royalties together exceeded £60,000,000 a year; it was published that the profits actually averaged £200 a year for every miner employed; and at least one of the men's leaders said that some of the owners took more in dividends than was paid in wages. Such were the statements that served to promote the national coal strike. Against these fictions let us place the facts—facts which, had the owners taken the trouble to place before the men, would have destroyed the fictions and prevented the strike, for the men would never have been persuaded to strike had they known the truth.

Taking the last five years for which we have the complete records, we get these bald figures:

UNITED KINGDOM COAL MINES

	Tons Raised.	Pit-Mouth Value.	No. of Workers.
1906.....	251,067,629	£91,529,266	882,345
1907.....	267,830,962	120,527,378	940,618
1908.....	261,528,795	116,598,848	987,813
1909.....	263,774,312	106,274,900	1,013,998
1910.....	264,433,028	108,377,567	1,049,407

Reduced to averages, these figures give us an annual output of 261,726,945 tons, raised by 974,836 workers, and a pit-mouth price of a fraction less than 8*s.* 4*d.* per ton. To simplify matters for a rough-and-ready estimate, let us put the price at a level 100*d.* per ton and strike off the odd 74,000 workers as being employed at the cokeries, by-product plants, etc. This leaves us with 900,000 men (and boys) to raise 261¾ million tons of coal in a year. To put it another way, we have a per capita output of 290 tons, or practically 1 ton per man per day, and the value is 100*d.* How much goes to labour and how much to capital? And what margin is there to permit of any substantial rise in wages?

Assuming that our 900,000 mine

workers get an average of only 30*s.* per week in wages, we get this:

ANNUAL AVERAGES, 1906-1910

Pit-mouth value	£108,661,591
Deduct wages at 30s. a week, 900,000 men	70,200,000
Balance	£38,461,591

to provide for rents and royalties, rates and taxes, timber, oil, rails, horse keep, etc., and capital charges all told. At this rate of wages 5*s.* 4½*d.* (within a fraction) would be taken out of the 8*s.* 4*d.* (within a fraction), which is the average value at the pit head. That would be 64½ per cent. for wages. According to the best authorities in the trade, labour takes 70 per cent. Of course, on top of actual wages, which we have put at a moderate figure from close knowledge, there are charges for miners' houses in districts where the men live rent free; cost of coal, which is supplied free or at nominal figures; payments under the workmen's compensation law, etc., which must bring the total labour cost up to 70 per cent., if not a little more. That would be 5*s.* 10*d.* per ton of coal raised, leaving 2*s.* 6*d.* for all other charges.

Now we come to general expenses. These vary between district and district. For example, while timber costs nearly a shilling per ton of coal got at some pits in Wales, it costs little more than 1*d.* at some in Durham. However, let us keep to averages. Taking the estimates of such authorities as Professor Merivale, for the Newcastle district, and of Mr. G. Blake Walker, for the Sheffield district, we may safelv put general expenses—that is, cost of rates and taxes, coal consumed at colliery, timber, rails, ropes, horse food, oil and general stores, management and sales commissions—all except labour, royalty and profit, at 1*s.* 6*d.* per ton of coal. This means:

	Per Ton.
Labour	5s. 10d.
General expenses	1 6
Royalty and dividend	1 0
Total	8s. 4d.

In totals the statement is something like this:

ANNUAL AVERAGES, 1906-1910

Tons of coal drawn	261,726,945
Value at pit-mouth	£108,661,591
Labour cost (including free houses, coal and compensation)	76,197,809
Balance	£32,463,782
Other costs and expenses, at 1s. 6d. per ton	19,629,520
Balance for royalty and profit...	£12,834,262

Here we have arrived at less than £13,000,000 a year to divide between royalties and dividends, against £76,000,000 for labour. Turning to inland revenue returns, we get these figures:

GROSS INCOME FROM MINES

(Financial Years)

1905-6	£19,999,000
1906-7	16,371,000
1907-8	16,400,000
1908-9	16,614,000
1909-10	18,460,000

These figures, it must be observed, cover iron, tin, lead and other mines, as well as coal mines, and they include income from costly by-product plants and similar sources. Then, again, it must not be forgotten that substantial depreciation charges have to be deducted from this gross income before net income is arrived at. Collieries are wasting assets, and the land also is often depreciated in value by the mining operations. Moreover, some companies spend many years and much money proving coal, sinking shafts, pumping water, and so forth, before there is any income. Sometimes there is failure to get the coal, and sometimes there are losses for many years when coal is being got. These losses ought really to be set against the profits to get a fair average. However, allowing for these items, it will be seen that the revenue figures in no way upset our estimate that royalties and profits on actual coal mining average somewhere about £13,000,000 a year, or 1*s.* per ton; and as royalties, including rents, wayleaves, damage to surface, etc., absorb about 6*d.* per ton, we are left with another 6*d.* or thereabouts as net profit. In other words, while labour gets very nearly 6*s.* a ton, capi-

tal only gets about as many pence. It is altogether wrong to imagine that coal owners' profits are abnormal, yet it is this idea that has been spread among the miners by false agitators, and it is this idea that is at the root of most of the trouble. If the coal owners' association had spread the facts among the men half as industriously as certain agitators have spread the fictions, events would have shaped very differently.

Apart, however, from the circumstance that the minimum wage agitation was characterized by gross misrepresentation, so far as the relative rewards of capital and labour were concerned, the very principle of the minimum is wrong, and its operation will prove disappointing—to the miners. To put the matter plainly, the Miners' Federation advanced an impossible demand and got the men to strike on a false issue. The demand as advanced, and as the men were led to understand it, was for a guaranteed daily wage something like equal to the average piece-work earnings, this to be payable almost regardless of output; but that in addition to this, and concurrently with it, the price list, or piece-work system, was to remain in operation, so that the men could still enjoy their customary high wages when in good places and working to the best of their abilities. The demand meant that the men were to have the combined advantages of both time work and piece-work, but none of the disadvantages of either system. The men were to retain the existing individual piece-work system, under which they generally earn good wages, and frequently high wages, but that they were also to be assured of an average wage on those days when their output fell below the average. Clearly, the thing is impossible. No Act of Parliament can make it possible, and it is just here that danger lies. The men have been led to believe that the profits of their industry are so large that not only can the customary high wages be paid for good work in good places, getting a big output of coal, but that at least average wages can be paid for poor work in bad places, getting a small output. We have already tried to make it clear that the average margin of profit is too small to permit of any substantial rise in the average labour cost. But the concession of the demand would have added very largely to the labour cost. It is not merely that the wages of those men earning at present less than the average would have had to be made up to the average, but that the guarantee of the make-up would have resulted in many men relaxing their efforts and reducing their production.

Suppose the minimum to be fixed at 7*s.* 6*d.* a day. Those men earning 10*s.* to 15*s.* a day might continue their efforts undiminished. But those earning only 1*s.* or 1*s.* 6*d.* more than the minimum when exerting themselves would conclude that the difference was not worth the exertion, and would relax down to a 6*s.* or 7*s.* level—those earning still less relaxing still more—but all assured of the full 7*s.* 6*d.* The aggregate output would seriously decline and the labour cost per ton would seriously advance, assuming new methods were not introduced.

It ought to be clearly understood that a minimum wage means a time wage, and that a time wage means supervision. This brings us to the crux of the problem—the problem that has not been solved, but seriously aggravated, by the Miners' Minimum Wage Act. Human nature being what it is, and the natural conditions of mining being what they are, the piece-work system is the best. Coupled with a reasonable arrangement for payment for work done in abnormal places—places in which the miner is prevented from earning fair wages owing to natural faults—the piece-work system is as near perfection as it is possible to get. The usual custom has been for special allowances, or consideration money, to be paid for work done in

abnormal places. What the amounts should be, and what should and should not constitute an abnormal place, entitling men to payment over and above the agreed tonnage figures, have always presented somewhat delicate problems; but upon the Eight Hours Act coming into force the difficulty was seriously complicated. The owners, finding their costs increased, have not been able to treat their men with the generosity of former days. On the other hand, the men, not permitted to work overtime to get through a fault, and their average earnings reduced, are more keen than formerly to have poor places declared bad in order to get the allowances. The men want more; the owners desire to pay less. Thus a tolerable grievance has been rendered well-nigh intolerable. When it was seen that the Eight Hours Act had intensified the difficulty, the coal owners frankly admitted the men's grievance and began to negotiate for a settlement. The obstacle was that the miners desired a full, or an average, day's wage when working in these bad places. Obviously, if the miner takes exceptionally high wages when in a good place he ought to be content with lower wages when in a bad place, getting very little coal, or none at all. Obviously, too, were wages to be as high for bad places as good ones, the men would have no stimulus to work through the fault to the normal again as quickly as possible, and the owners would have little or no guarantee of fair labour.

However, while negotiations on the abnormal place difficulty were proceeding, with every prospect of a satisfactory settlement in most districts, the Miners' Federation, captured by a school of extremists, sprung a demand for an all-round minimum wage for all places, good and bad, and for all men, and altered its rules so as to authorize a national strike in case any district failed to get full satisfaction. The history of subsequent developments is fairly well known. The demand was impossible. Negotiations broke down. A majority of the union men voted for a strike. There was a strike. The Government did not allow the strike to run its natural course. It did not even assure the men desirous of working the protection of the law. Indeed, the Government, badly advised, in spite of its multitude of Board of Trade officials, its Labour Department, and its special labour advisers, prolonged the strike and raised false hopes among the strikers by the promise of legislation. A measure has been passed enacting the principle of a minimum wage for underground workers, stating no figures, but setting up joint boards, representative of the employers and workmen, with independent chairmen, to settle the pay rates for the various districts. Thus we are brought to a novel state of affairs. The situation must be carefully handled and the developments closely observed.

The coal owners are faced with a complete set of new difficulties. The strike has served to demonstrate the weaknesses of the new trade unionism and to discredit the national strike movement and its leaders. That is something to the good. But the Minimum Wage Act is a doubtful quantity. It settles very little. It leaves nearly all the cardinal points in the dispute—the district rates of pay, the grade rates, questions of aged and indolent men, of the so-called "safeguards" against malingering, and, above all, the difficulty of blending a time wage system with a piece system—to be settled by the joint boards. Certainly this brings us back to one root principle from which we ought never to have departed—the principle of regulating industry according to local conditions. But when the new joint boards have done all they can the coal owners will still be left with about the biggest task that has ever fallen to the employers in any industry in any country, and upon the method that

task is performed much depends—much of vital national concern. The various questions of collective bargaining, of trade union recognition, and other debatable problems are thrown into the melting pot. How will they emerge?

There is the question of old agreements, for example. Hitherto the relations between capital and labour have been governed by county or district agreements, made in accordance with local conditions. The unions have had the fullest recognition for many years in this industry, and these coal trade agreements have been among the best collective bargains in the world. Natural conditions varying widely between district and district, obviously separate district agreements are the best. But the Miners' Federation—that is, a national federation of the local unions—has aimed at uniformity, and a big step in that direction was taken when the Federation persuaded Parliament to enact a Miners Eight Hours Law. This uniform law has done much harm in some districts, but it was followed by a movement for a national minimum wage. However, when the Eight Hours Act became operative, collective bargaining had had one or two hard knocks. The men in some districts struck against the agreements made by their leaders. The owners overlooked these breaches and still continued to negotiate with the union officials.

Now the situation is entirely changed. The Federation itself has broken district agreements by ordering a national strike, and to end the strike the Government has set up statutory tribunals to regulate wages. What, then, is to become of the old district agreements? By the men and by their Federation these agreements have been violated, and the violation has been sanctified by Act of Parliament. In spite of this the men expect to retain all the advantages of these agreements, in addition to their new statutory minimum wage. But can the owners afford it? Can they afford to pay higher wages under the new law to the lower paid men in the pits and at the same time pay the highest current wages to the best workers? From the figures we have quoted it seems hardly likely. Besides, the price of our coal is already at a level which permits successful foreign competition, and cannot be put higher without serious consequences. If, therefore, the coal owners content themselves with a simple observance of the law and ignore the old agreements which men, Federation and Parliament have joined to tear up, who can blame them?

Another vital point that arises is that of representation. After initial difficulties are got over, who are going to represent the miners on these joint boards? Strictly speaking, representation by union delegates will fail to effect the purpose of the new law. The law is to apply to men, as men, and not as unionists. Moreover, this new and statutory method of wage-fixing renders trade unionism something like obsolete. If only union delegates are to represent the men the representation will not be fair. To begin with, there were between 200,000 and 300,000 mine workers who owed no allegiance to the unions when the strike started. There were over 100,000 union members who voted against the strike. Now the strike is over large numbers are threatening to leave the unions. It is a question whether the Federation will retain even half the men, now there is such deep disappointment. The frequent breaches of agreement, the passing of the Minimum Wage Act, the disposition of the unionists to break, or ignore, the new Act immediately it was passed, just as they broke the old voluntary bargains, and the fact that a large proportion of the men are non-unionists, all combine to make the case for full and fair representation on the boards — representation of all the men—unanswerable. In any case, the Federation has forfeited its right—always a doubtful one—to

special recognition, and it will not be amiss if we come back to the principle of the conduct of industry by employers and workmen instead of agitators.

Another difficulty presented by the Minimum Wage Act is the question of wage readjustments. These must be so effected that the total labour cost of coal is not increased. In other words, if some men's wages are leveled up some other men's wages will have to be leveled down. Again, if the new Act is interpreted as applying to piece-workers, as well as day-wage men, and a comparatively high minimum daily wage is fixed, strict supervision will have to be exercised. This will, no doubt, involve the universal adoption of the "butty" system. This system has proved repugnant to the men when and where introduced, but the minimum wage must carry its evils as well as its benefits. Under a time wage system there must be supervision, and as this is more difficult to exercise in a mine than a workshop, the "butty" system seems the only solution. This means that a kind of contractor, called a "butty," agrees to get the coal out of a number of places—a big stall or a longwall—at tonnage rates, employing the necessary hewers, timberers and trammers under his own personal supervision. This means, further, that the actual workers will have to labour at a piece-work speed for a time wage. The minimum is almost sure to become the maximum. Average wages will be reduced. Aged and delicate men will be weeded out, and the young and strong will be speeded up.

Another certain effect will be the introduction of more mechanical coal cutters. Hitherto we have been backward in this respect, partly because organized labour has set up vigorous opposition to improvements. With unions weakened, the opposition will be less strong now. A few of the poorer seams—those employing the most labour per ton—may be abandoned, but by mechanical improvements and the "butty" system in other seams output will be maintained and labour costs at least kept from rising—probably materially reduced.

Then there will be the more economical consumption of coal to be reckoned with. Householders will waste less coal in future. Improvements will be effected in furnaces. Sewage gas for street lighting and more blast furnace gas in iron works will be used. More oil, more electricity, more water-power, and possibly wind-power, will be employed. The nation's per capita demand for coal is almost sure to decline. This will keep prices down, and, in turn, it will depress the wages, as well as curtail the employment of miners. Engineers and coal consumers will benefit, miners will suffer, colliery owners will have less dictation from agitators, and trade unionism, if it survives the big blow it has sustained, will return to saner and soberer methods. Workmen will be more careful in the choice of their leaders after this.

THE IRON RESOURCES OF BRAZIL

THEIR INFLUENCE UPON POSSIBLE COMMERCIAL RELATIONS WITH THE UNITED STATES

By John Brooks Elgar

FOR a long time the United States has been content to take part in the development of its own natural resources; and with reason, since the past twenty or thirty years have seen its rapid strides forward as a world-producer, not only of raw materials, but also of finished products. There have been two elements in progress in which, however, the United States has been behindhand and passed, not only by such Powers as England, Germany and France, but by smaller nations as well, and these have been in the development of the merchant marine and in the exploitation of its nearest neighbour, South America.

In the present century these two factors seem destined to offer greater and greater opportunities. France is devoting her attention to Morocco, Italy to Tripoli, Germany to her African territories, while England has her dominions beyond the seas, including Canada, Australia, India and Africa. The United States, while possessing no dominion over any territory in South America, has at her door the commerce with these friendly nations, to which she should devote her best energies, cementing business relations, and bringing about connections for the present and for the future.

Many people in the United States think of South America only as a land of wild animals, malaria, excessive heat and revolutionary populations. As a matter of fact, these conditions are shared only with similar affairs in other parts of the world, while there are other features which should be given importance on the other side of the account to their full value. The malaria and fevers which were at one time so prevalent in South American ports are being wiped out altogether in the southernmost cities and decreased to a very low percentage in the cities and towns of the north. This result has been brought about largely by the expenditure of large sums of money in sanitation work. The heat is excessive only in those countries nearest the equator, and there it is tempered with cool breezes at night, which enable the residents to stand the intense heat of mid-day. So far from being lovers of revolution, the people are decidedly fond of peace, liberty and national prosperity, as shown in the remarkable progress during the past twenty or thirty years of the foremost South American nations—Brazil, Argentina, Uruguay and Chile—which make up by far the greatest part of South America, and have been moving steadily forward, showing themselves to be in the rank of the foremost world powers. Of these nations, one of the greatest is probably Brazil, especially when considered in connection with her natural resources.

The cities of Brazil are well sanitated, old buildings are being replaced rapidly by modern ones, broad streets are being laid out, well paved, and furnished with both gas and electric lighting. Electric tramways and automobiles are seen as frequently as in other countries, and the industries and foreign credit of Brazil are keeping pace with those of other countries. The government offers inducements to emigrants to settle in its

CENTRAL AVENUE, RIO DE JANEIRO

land and welcomes investments of foreign capital in its industrial enterprises.

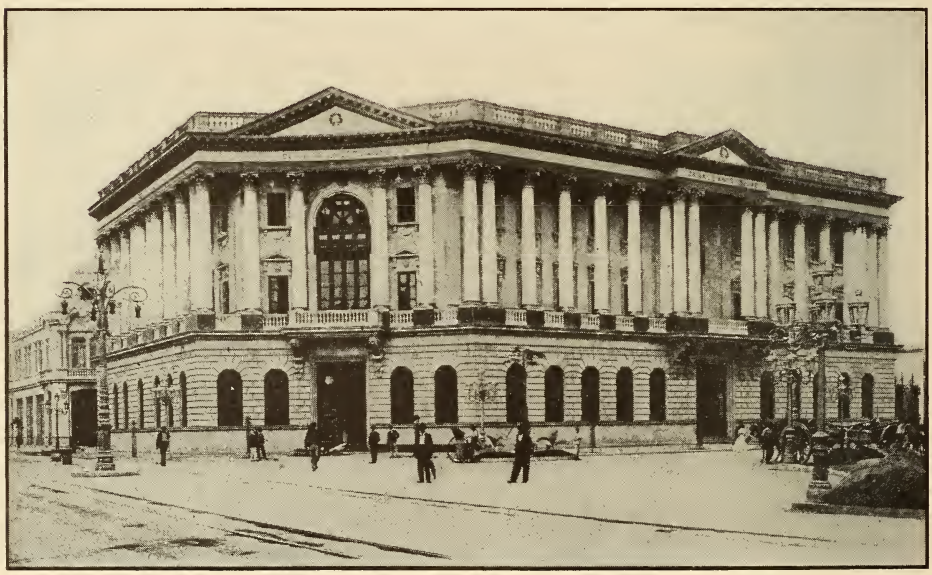
The future citizens of Brazil will be made up from the amalgamation of various races. At one time Holland had a colony in Northern Brazil, and traces will still be found in this section of Brazilians of Dutch descent. The importation, however, of African negroes into the northern portion of Brazil has done much to obliterate the European blood in this part of the country. Further south the greater portion of the population is descended from Portuguese, Span-

RUA URUGUAYANA, RIO DE JANEIRO

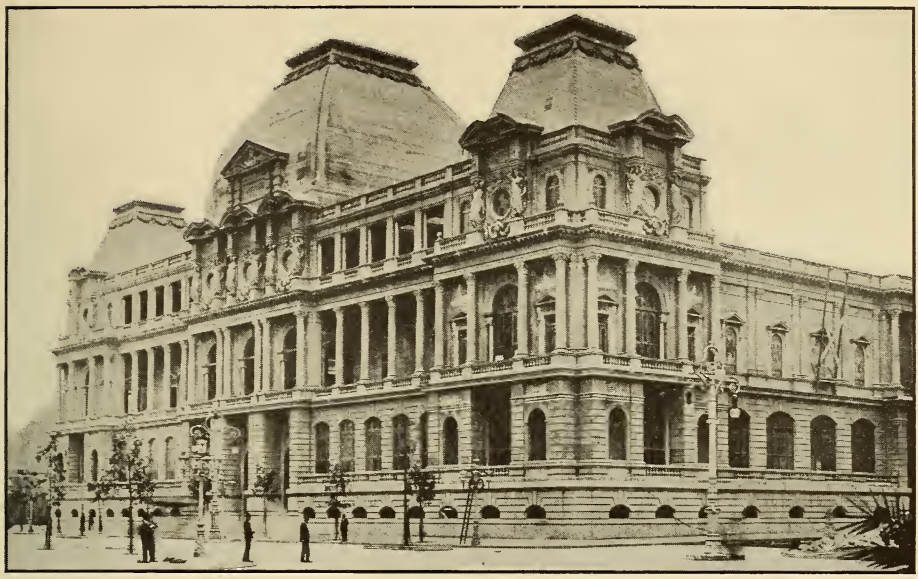
VIEW ON CENTRAL AVENUE, RIO DE JANEIRO

ish, English or German ancestry. Still further south English and German blood is found in greater abundance, until, in the State of Santa Catharina, one finds towns made up largely of Brazilians of German extraction. The native Indian is also leaving his imprint on the future race of Brazil, though his progeny is usually found some hundreds of miles back from the coast, where, in some cases, Indian tribes still exist in the same primitive state as when Brazil was first discovered.

The amalgamation of races now settled in Brazil, together with the

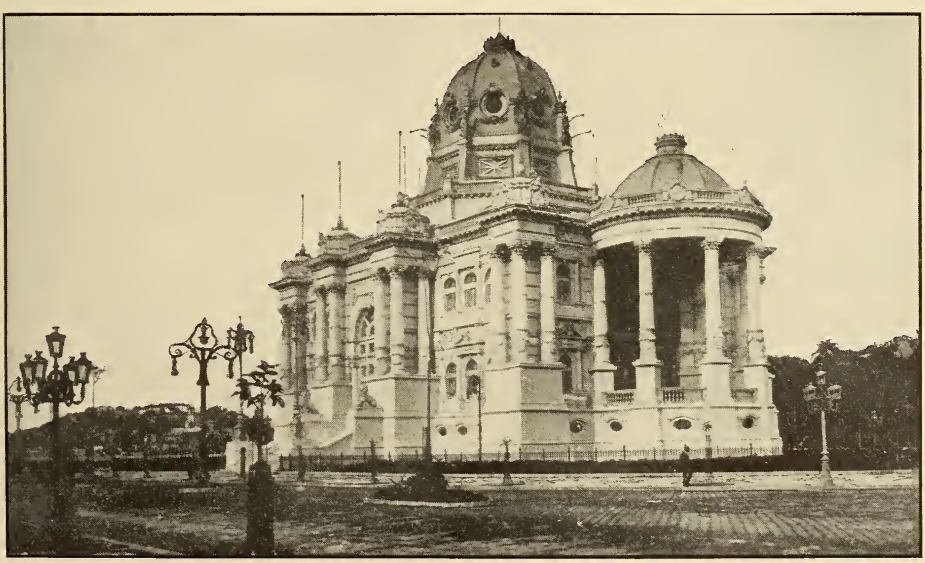


AMORTIZATION BANK, RIO DE JANEIRO



NATIONAL ACADEMY OF FINE ARTS, RIO DE JANEIRO

continued influx of immigrants from Central Europe, fostered by favourable legislation and attractive inducements, will certainly result, in the course of the next few generations, in the production of a people as active and vigorous as has been developed by a similar amalgamation in the United States. It remains for the action of the people of the United States to determine whether they will join in this progress, becoming personal friends of Brazil, entering into the development of her wonderful natural resources, or whether they will stand apart, leaving this develop-



THE MONROE PALACE, RIO DE JANEIRO

A COFFEE PLANTATION, RIO DE JANEIRO

ment to be made mainly with European nations.

Back in the heart of Brazil there are immense forests of the choicest and rarest woods; in other sections rubber is found in such abundance that even now the greater portion of the world's supply is taken from Brazil; more than one-half of the coffee product of the world comes from Brazil. Other products already being developed include hides, to-

NICTHEROY AND THE BAY OF RIO DE JANEIRO

PLACE MARECHAL FLORIANO AND THE MUNICIPAL THEATRE, RIO DE JANEIRO

bacco, cacao, cotton, sugar, wax, monazite, precious stones, gold, etc. According to the Consular Trade Report of June 3, 1911, the value of coffee exported by Brazil in 1910 was $127,212,875, of which the United States took to the value of $58,808,467. The rubber exports reached a value of $124,400,714, the United States taking $47,409,030. Manganese ore worth $1,887,747 was exported, of which the United States took $435,905. Gold bullion amounting to 3,625,536 grains, with a value of $1,945,690, went to Great Britain, while no shipment of gold bullion

BAY OF BOTAFOGO, RIO DE JANEIRO

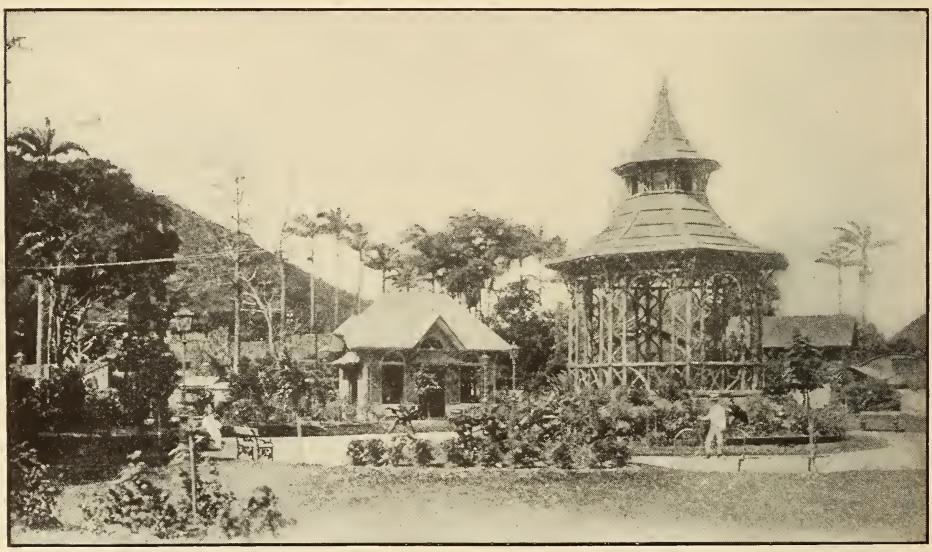
VIEW IN THE PARK OF THE REPUBLIC

was made to the United States.

We quote further from the same source: The immigration into Brazil in 1910 amounted to 88,564, made up as follows:

Portuguese	30,857
Spanish	20,843
Italian	14,163
German	3,902
French	1,134
Austrian	2,636
Dutch	197
British	1,087
Argentine	477
Uruguayan	144
American	344
Turkish-Arabians	5,257
Russians	2,462
Japanese	948
Others	4,113

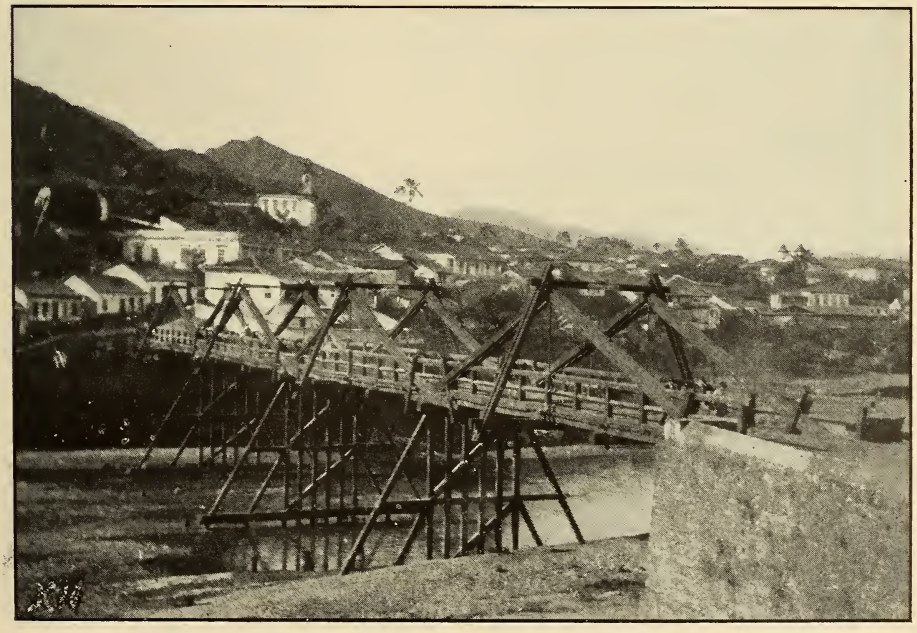
England now has many enterprises in Brazil, which tend to foster British interests, these including railways, banks, mining enterprises, etc., and



PLACE BOA VISTA, RIO TIJUCA

VIEW IN THE STATE OF MINAS GERAES

all these aid in building up British trade. Germany, France, Italy, Portugal and other nations are endeavouring to attract Brazilian trade, both present and future, while the United States sits calmly by, content with the development of the resources within its own borders.



HIGHWAY BRIDGE, MINAS GERAES

RAILWAY UP MOUNT CORCOVADO

A latent power possessed by Brazil, which has just been awakened, appears in the fact that within her borders there are deposits of iron ore of immense size and best quality; and the next important step in her national growth lies in the development of these resources, either by herself or by other nations. This fact is well appreciated by all who have visited Brazil during the past three years.

The business prosperity of the United States is closely bound up with its iron and steel trade, and it is fair to presume that the future commercial greatness of Brazil will become connected with a similar development. This must be admitted when it is realized that Brazil possesses enormous deposits of iron ore of the highest grade.

The State of Minas Geraes contains untold millions of tons of iron ore, running from 50 to 68 per cent. of metallic iron and very low in such injurious elements as sulphur, phosphorus, etc. The following analyses of a number of average samples will bear out this statement:

LANDSCAPE IN THE STATE OF MINAS GERAES

APPROACH TO IRON MOUNTAIN, SERRA DO CARACA

BRAZILIAN IRON ORES

Fe.	Sulp.	Phos.	Titan.	Sil.	Al.	Man.
57.96	.080	.092	0	3.56	2.49	.43
66.07	.014	.151	0	2.00	.77	.43
69.75	.082	.005	0	.90	.20	.37
64.84	.007	.124	0.50	1.74	.42	.40
66.82	.048	.102	0.61	.55	.82	.38
56.24	.076	.076	0	19.75	.70	.44
67.04	.027	.110	0	5.04	.66	.39
57.70	.030	.025	0	17.75	.42	.40
46.02	.036	.160	0	33.95	.42	.38
55.26	.140	.030	0	.60	3.14	9.20
60.90	.170	.107	0	.62	4.90	1.00

The names of some of the best-known deposits are: Serro de Caraca, Serra de Itabira de Matto Dentro and Serra de Itabira do Campo, all of which include in themselves many square miles of high-grade hematite ore, running between 50 and 65 per cent. of metallic iron, and totaling unknown millions of tons.

From the Brazilian Year Book of 1908 (p. 556) we quote the following: "The principal iron outcrops have so much in common that a description of one will more or less apply to all. The most favourably situated is, perhaps, the peak of Itabira do Campo, only two and a half miles from the Central Railway, and towering some 1,600 feet above it. The deposit is about 150 feet thick, and the whole peak proper, some 500 feet high, is composed of the pure mineral. Huge boulders of the pure ore, fallen from the peak, encumber the flanks of the mountain, and the lower slopes are covered from ten to fifty feet deep with a pure rubble washed down from above.

"From this description it is clear how the work of extraction and transport is facilitated, and at how low a cost the mineral can be placed on the line.

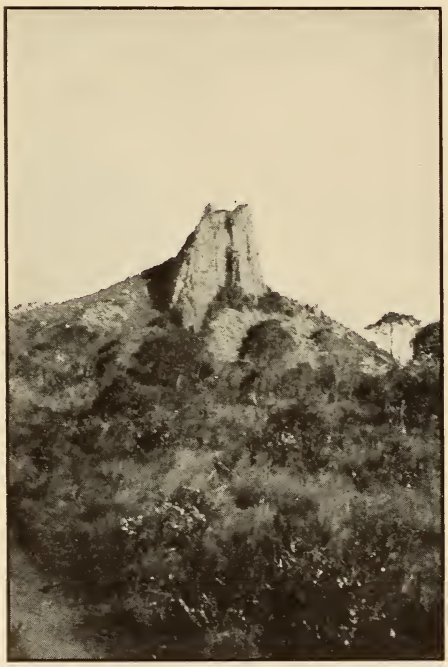
"Another immense deposit crops out along the flanks of the Caraca range, more impressive and certainly superior in volume to that previously alluded to. At present the railway is twenty-two miles distant, but a line is projected which will pass close to it. The outcrop extends without a break for twenty-five miles, and the thickness is little, if anything, under 150 feet. The total mass is somewhere in the hundreds of millions of tons.

"Another great outcrop is that of the Itabira do Matto Dentro, seventy-five miles from the Central Railway.

PEAK OF ITABIRA DO CAMPO

The Leopoldina Railway, however, will pass close to it.

"All three of these deposits—there are many others, not equal in importance to them, but still of great size and importance—are worthy of the often, but rarely justified term, mountains of iron."



IRON PEAK, ITABIRO DO CAMPO. AN OUTCROP OF SOLID ORE

Upon a previous page of the same book is given the following, in relation to the quality of the iron of these same deposits:

"They run from 65 to over 70 per cent. of iron, the latter being due to their containing a certain percentage of the richer magnetic oxide."

An article in this connection was published in the Daily Consular and Trade Report (Saturday, June 3, 1911, p. 989) by J. J. Schlecht, U. S. Vice-Consul-General to Brazil, entitled "Commercial Review of Brazil":

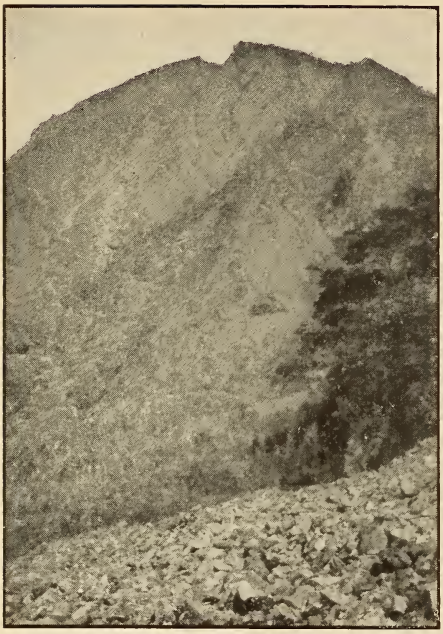
"An interesting feature of mining development during the year was the discussion of the latent possibilities of the iron ore fields in the State of Minas Geraes, constituting what is undoubtedly one of the greatest sources of iron ore known to exist in the world. Electrification of a railway from Victoria to Itabira, the latter a station in the State of Minas Geraes, was begun, this railroad to serve as an ore carrier for a British syndicate which has acquired holdings of important ore deposits in the State mentioned. Not less than four important American concerns have sent experts in ore and in the examination of titles to investigate the prospects in the iron industry, none of whom, so far as known, have

FORMATIONS NEAR ITABIRA DO CAMPO

taken title to any of these properties.

"Important reduction in freight rates were provided for in administration decrees issued in 1910, and these favours have since taken the form of special concessions to domestic concerns, supplemented by special favours in the way of bounties on

AN ALL-DAY RIDE OVER IRON ORE



IRON MOUNTAIN, SERRA DO CARACO

iron and steel production and special concessions in charges in shipping in the interests of exportation."

On December 7, 1911, Decree No. 8,414 was issued by the Brazilian Government at Rio de Janeiro, granting to Señor Carlos Wigg and Señor Trajano Veriato de Madeiro certain concessions in connection with their proposed erection of iron works to develop the native iron ore deposits and for the development of an export trade in iron ore. On February 22, 1911, another broader decree—No. 8,579—was issued with the same end in view, and plans are now under way to finance the plans with the aid of British capital. The value of these great deposits of iron ore is gradually being appreciated in Brazil, and the next few years will undoubtedly see great progress made in their exploitation.

With this development of the iron industry of Brazil it seems as if the way might be opened for commercial relations with the United States which would result in improved business prosperity to a marked degree. Possibly the formation of an organization in which capital of both coun-

APPROACH TO IRON MOUNTAIN, SERRO DO CARACA

IRON ORE LAND, MORRO VELHO

tries should be interested would find ample opportunity for the development of Brazilian iron ore, for the shipment of ore to the United States, and for return cargoes of American coal or coke, as well as for the manufacture of iron and steel products in Brazil for local use. If such an international company could be formed, it would aid materially in developing both the natural resources of Brazil and the commerce with the United States, in addition to the development of a merchant marine.

According to the number of the Consular Report previously quoted, it appears that there are 13,372 miles of railway in Brazil, 1,189 miles of

ALONG THE ORE PATH, MORRO VELHO

which were built in 1910. The value of rails, etc., imported into Brazil during 1910 was $6,571,588, of which the United States supplied only $899,-771. Brazil imported coal in 1910 to the value of $11,737,701, of which America supplied only $365,-527. Other finished iron and steel products imported by Brazil during 1910 were: Corrugated iron, structural material, iron and steel bars and rods, tubes, etc., also railway rolling stock. The total value of the imports into Brazil in 1909 was $179,690,125, and in 1910 the imports reached a value of $235,754,837. The exports in 1909 amounted to $308,-331,829, and in 1910 they were $310,006,438. From the same Consular Report it may be learned that 5,149 foreign steamships entered Brazilian ports in 1910, bearing a total of 13,397,698 tons, besides 360 sailing vessels, aggregating 193,817 tons. During that year only 8 vessels, of 8,129 tons, carried the American flag into Brazil.

The advantages to be derived from some such joint commercial organization as that indicated may be seen when the value of a fresh supply of high-grade, low-cost iron ore to the pig iron producers of the Eastern United States is realized. Much of the ore now smelted in the East now comes from foreign countries, and an increase of this supply would not affect materially the operations of iron mining in the interior of the country. The greater competition which this stimulus to the steel industry would bring about would include greater ability to enter the markets of the world with other nations. The development of the merchant marine consequent upon this commerce between Brazil and the United States in iron ore would extend to other lines of commerce and aid materially in stimulating broadly the trade relations between the two countries.

Similar advantages would accrue to Brazil by the development of such relations in the iron and steel industry. One of her richest natural resources would be rapidly developed by a country of great experience in the conversion of ore into finished products. This would be accompanied by a stimulus of iron and steel manufacture within Brazil herself, enabling her to produce rails and other material for her own railway development, while the industrial activity thus produced would attract energetic immigrants and extend her own internal growth.

THE REPLACEMENT OF THE MAN BY THE MACHINE

By Henry Harrison Suplee

EVER since the introduction of mechanical power as an aid to human effort there has existed a controversy, sometimes academic, sometimes violent, about the influence of machinery upon human welfare. Into this discussion, as a discussion, it is not intended to enter at the present time; but rather is it proposed to indicate the progress which is being made in the introduction of power-driven machinery to replace human effort in its more laborious forms; considering it as a means of doing things which should not be done at all by men, either by reason of the excessive muscular or other physical strains produced or because of the hurtful after effects upon various parts of the human organism.

It must not be presumed that the men who have devised and introduced power machinery were moved to do so because of any philanthropic motives to better the condition of their fellow men; neither should it be maintained that the real motive of such developments had its origin in any deep-laid plot to deprive men of the opportunity to work. Any study of the historical development of the fundamental inventions which have worked such changes in the industrial and commercial world will reveal the fact that the men by whom modern power-generating and utilizing machinery has been invented have been rather retiring and uncommercial individuals, often having great difficulty in inducing manufacturers and capitalists to consider their ideas, and generally being the least among those who have reaped the material profit of their efforts. Watt was a retiring and modest student and model maker; Fulton a portrait painter, with a taste for mechanics; Stephenson a hardy coal miner; while Cort, Bessemer, Mushet, Gilchrist, Thomas—the men who made the present steel industry possible—cannot be considered, by any stretch of the imagination, as having as incentives any deep-laid plans to injure their fellow men. It will be found that the inventor, as a general thing, becomes absorbed by the problem which he has set himself for its own sake, and works it out as he would the conclusion of a profound game of chess, looking, it is true, for some moderate financial reward if successful, but content to let his production become such a part of the social organism as the struggle of forces in the progress of industrial evolution may determine.

Even the capitalist and manufacturer, the men by whom the improved apparatus is put to work, usually reluctant to take up with any new thing, find the principal inducement to develop an invention to be, as a general thing, the necessity for accomplishing some task for which the older equipment is found to be inadequate.

The original commercial existence of the steam engine was due to the necessity for removing from the mines of Cornwall the immense volumes of water which were impeding the workings of the miners, and which could not possibly be handled by human effort. Both the steamship and the railway owe their existence to the limitations of the older methods of transport, and not to any desire to cheapen the cost. The steam

hammer was produced by Nasmyth only because the older helve hammer could not forge a shaft which the increasing dimensions of steamship design demanded. Usually it will be found that the ability of machinery to increase output and efficiency over older methods has not been fully perceived until after the necessity for the introduction of apparatus of greater capacity has become irresistible, and these results, themselves causes rather than effects, are even now but faintly realized.

Nevertheless, the industrial revolution which may be placed as having its beginnings with the general introduction of steam power about the time of the expiration of the Watt patent at the commencement of the nineteenth century, has proceeded with ever-increasing rapidity and with corresponding modifications in the social order. It has been frequently opposed and often forcibly denounced, but at no time has its progress been checked, and hence it is much more desirable to endeavor to examine just what its advance may be expected to produce than it is to expend effort in vain attempts to change its course.

Possibly the best foundation which can be laid for the erection of a satisfactory superstructure in this matter will be obtained by a rapid glance at the history of its development.

The primitive man, with nothing but his unaided hands to serve him in the struggle for existence, was not so well off as the strong and fierce beasts with which he had to contend, except in the greater intelligence which he possessed. It was this very intelligence which led him to produce tools of continually increasing effectiveness and to maintain and advance his position. The single element of fire was to him as great a boon as the steam engine has since been to his descendants, and to consider the one as a friend and the other an enemy reveals the curious distortion in perception which is sometimes produced by differences in lapse of time. The same is true of the use of the lever, the roller, the inclined plane and other simple mechanical devices which primitive man called to his aid to accomplish undertakings beyond the capacity of unaided human muscle. The monuments of ages past indicate the extent to which man must have used some kind of mechanical appliances; but apart from certain devices constructed to aid in warfare in medieval times, the employment of apparatus operated by manufactured power must be considered to date from about the beginning of the nineteenth century.

As has already been indicated, the first employment of the steam engine was to perform work for which human effort was unequal—the pumping of water from the flooded mines of Cornwall. From this its services were extended to the driving of flour mills, and the operation of textile machinery; and before long the beginnings of the factory system were in evidence.

It is about the factory system and its development that the principal controversies concerning the advantages and disadvantages of machinery to the world at large have arisen, the work of textile manufacture being increased in scale rather than in kind by the increased output made possible by power-driven spindles and looms. The so-called Luddite riots, which arose because the operatives believed the machinery to be the cause of their distress during the early years of the nineteenth century, may be cited as one extreme instance of this phase of the subject. It is only by a broad survey of the influence of this class of machinery that correct conclusions may be drawn, and with such a view of the period it appears that in the departments of industry in which machines have replaced actual human muscular effort the opportunities for employment have been increased and not diminished, while the demand for workmen for the manufacture of the

new machinery itself has meant the creation of an entirely new volume of work, furnishing employment which previously had no existence.

Turning, however, to the development of machinery for effecting operations wholly beyond the unassisted capacity of human effort, we find here some of the most remarkable results in the history of mankind.

Taking the original service of the steam engine, that of pumping water out of mines, this application of manufactured power alone has enabled a great number of workings to be continued which would otherwise have been abandoned. The extension of service for pumping water to other purposes made possible the provision of ample water supply to cities to which it could not be delivered by gravity, and thus became one of the factors by which the death rate has been greatly lowered during the past century. Applied to power navigation, the steam engine has transformed the commerce of the world, and at the same time has made it practicable for the excess population of the older settled portions to be distributed over areas in which greater opportunities for sustenance and comfort could be secured. Similar results have followed the development of railways, results which, when striven for by the feebler efforts of men provided with sailing vessels or sought by small expeditions with animal transport, were greatly hampered and curtailed.

The human efforts replaced by these means, however, form a limited class, and their influence is more clearly apparent than some of later development. Labour, as generally understood, means hard work, *very* hard work, leaving the labourer fatigued beyond wise limits, and producing in him a sort of brutalized influence which under no kind of reasoning can be considered desirable. Such labour appears in the operation of puddling, for instance, in which a man, stripped to the skin and protected from radiant heat after a fashion by a sort of leather shield, works and kneads a ball of iron upon the hearth of a reverberatory furnace until the proper proportions of carbon and slag have been eliminated. A similar kind of brutal labour is yet required in the operation of stoking the furnaces of ocean steamships, and to these may be added, as similar but less brutalizing, the older methods of handling heavy materials which involve straining and lifting beyond the evident capacity of endurance of human muscle.

Some of these operations have already been transferred to mechanical appliances, and the Bessemer converter is now doing much of the work formerly consuming the bodies of vigorous men. There has been less success in replacing the work of the man in the stokehold by a satisfactory mechanical appliance, but it is more than probable that the introduction of liquid or gaseous fuel and the general employment of the internal-combustion engine on shipboard will remove entirely the necessity for any manual effort in handling fuel directly in front of the furnace.

It is not always easy to obtain quantitative data concerning the extent to which a mechanical device may relieve men from exhausting labour and at the same time increase immensely the efficiency of the operation; but the figures are available in some cases, although it is found necessary to compile them from several sources.

Thus, the very laborious work of handling pig iron has been examined by an excellent authority, and in his important paper upon "Shop Management," presented before the American Society of Mechanical Engineers by Mr. F. W. Taylor, in 1903, it is stated that the ordinary work of a man, loading pig iron from the ground upon a railway car, was from 12 to 13 tons per day. Under a scientifically managed task system, however, utilizing the man's effort to better advantage and stimulating him by the increased wage obtainable by piece-

work, the daily result was raised to 45 or 48 tons.

The introduction of the lifting magnet, however, has rendered it unnecessary for this laborious work to be performed by human effort at all, and the results, as given in the unloading of the steamship *Erwin L. Fisher,* at Indiana Harbour, Ind., give the comparative figures for the man and the machine. With a cargo of 4,000,000 pounds of pig iron, the time required to unload this vessel with twenty-eight men was two days and two nights, which corresponds to about 3,000 pounds per man per hour, or about 15 tons per day of ten hours, agreeing very well with Mr. Taylor's figures under ordinary day's work. When the lifting magnet was introduced, the total time required for unloading was reduced to eleven hours, and this was done by two men, whose labour consisted in manipulating the controllers in the cages of the cranes. Thus two men and two magnets did the work of twenty-eight men in less than one-fourth the time. Under these conditions the handling capacity of a man and a magnet was nearly one thousand tons in eleven hours, or about 900 tons per day, or twenty times as much as was possible under scientifically managed manual labour. Furthermore, the operation was chargeable with less than one-fourth the amount of overhead charges, while the vessels were enabled to double their number of productive trips.

In this connection it is interesting to note that knowledge of the extent to which the lifting magnet is able to relieve men of exhausting physical labour, a kind of information rather difficult to obtain directly from the manufacturers by whom such apparatus is used, has been made public by the men themselves. It appears that at the Homestead Works of the Carnegie Steel Company, according to the observations of Messrs. Korngold and Hood, published by the latter in an article in the Milwaukee *Social-Democrat Herald* for August 12, 1911, two lifting magnets, operated from traveling cranes, unloaded scrap and pig iron formerly requiring the labour of twenty-five men.

"Further inquiry developed the fact that the two young men operators of the cranes and magnets did the work so rapidly that they were employed only a part of the time, while the twenty-five men who formerly did the work were employed all of the time.

"In fourteen other parts of the works we found the same kind of magnets had performed the same kind of service in the way of decreasing the pay-roll lists, which, in cold figures, means that twenty-eight men are now employed part of the time where formerly it required 350 workmen to remain constantly on the job."

Another example, and one of the oldest in the general introduction of machinery to do work which manual effort cannot do to advantage, appears in the application of the Whitney gin to the removal of seed from cotton fibre. The amount of cotton which could be cleaned by hand amounted to only about a pound or two per day, while with the improved gins the amount was so immensely increased that it is not too much to say that the entire immense cotton industry of England and America has grown out of the increased supply of raw material made possible by this single piece of machinery.

Closely allied to the development following the cotton gin there may appear the increased production made possible by the utilization of machinery for picking cotton. It is stated that the present production of cotton in the Southern States of America, amounting to ten or twelve million bales per year, might be more than doubled if it were possible to pick such a crop. The available supply of colored labour for cotton picking during the harvest season is the limiting element, and if it were practicable to pick a greater crop it might

readily be grown. The Campbell machine, which has been exhaustively tested in Texas, has, it is stated, a capacity of 6,400 pounds of cotton a day, or more than twelve bales. This corresponds to the work of thirty skilled cotton pickers, and includes the services of one man and a boy, the cost of operation being about $6, compared with $50 for picking the same amount by hand. Here the machine may benefit the entire community, not so much by displacing human labour as by enabling a greater area to be placed under cultivation. In this respect the cotton picking machine may work a similar revolution to that effected by the reaper, extending the possibilities of agricultural development far beyond the limits imposed by purely manual labour.

Since agriculture is, and will naturally remain, the greatest industry of all, the application of machinery to the more efficient production of the food supply of the world becomes most important. Notwithstanding the development of harvesting machinery, it is stated that only about 5 per cent. of the agricultural work in the United States is mechanically performed. At the same time it is well known that the difficulty in obtaining sufficient men to handle the crops constitutes one of the greatest impediments to the proper development of maximum efficiency in agriculture. The general introduction of manufactured power, either by the use of oil engines for traction and local power generation or by the development of central hydro-electric stations, distributing power over considerable areas, will enable the replacement of human labour to be effected, or, rather, the deficiencies of human labour to be supplemented, with the result that the productive capacity per acre may be doubled and no greater area be required for a long time to come. If, as has already been demonstrated, it is practicable to use vegetable oil to advantage in internal-combustion engines of the Diesel type, the agricultural industry may, in the future, be able to supply itself with all the fuel necessary for its own development, and thus become independent of external sources of fuel supply.

There have been mentioned only a few of the devices by which the burden of human labour has been lightened by the use of machinery, while the capacity for accomplishment has been increased, and numerous others will suggest themselves. The elevator and the telephone were required before the tall building could be used to advantage, even after the production of structural steel made such construction practicable. All the manifold applications of electricity have resulted in the relief of many from burdensome toil, while providing new and lighter occupations for thousands. It is unnecessary to enumerate the immense number of such developments within recent years, and it is impossible to predict their future extension, except along the most general lines.

It is important, however, to remember that the human machine, considered as a means of producing mechanical effect, is far too costly and too lacking in efficiency to be used for anything which can be done by manufactured power. Any idea that there is an inherent dignity or merit in overstraining human muscle in a wholly undesirable and inefficient manner must be replaced by the certain knowledge that the true method of employing man is by the use of his trained judgment and skill in the control of manufactured power applied through properly designed machinery.

From what has been said, it will be evident that the kind of labour which is most readily replaced by machinery is that of the untrained man who works principally with his muscle, and that the performance of this portion of the world's work by machinery will mean that the man who is to earn his living by his labour must be capable of using his

head as well as his hands, and learn how to do things at the same time lighter and more valuable than formerly. Anyone who is at all familiar with the development of the work of the machinist during the past fifty or sixty years will realize the extent to which this has already been effected. The old-time apprentice learned how to chip and file and fit. He even acquired the knowledge and skill demanded by the old-fashioned hook tool in the hand lathe, and could chase screw threads with a degree of accuracy wholly beyond the capacity of the present-day mechanic. The advent of the planing machine, the milling machine and the grinder has changed all that, while the turret lathe and the entire army of automatic and semi-automatic tools stand ready to do the work far better and more rapidly than any hand labour could possibly perform it. These facts, however, have raised the craft of the machinist rather than lowered it, and the modern mechanic has, in the modern tools with which he works, as great an advantage over his immediate predecessor as the latter possessed over his forefathers.

The replacement of the man by the machine, therefore, must be accompanied by an entirely different kind of training from that formerly supplied by the old apprenticeship system, or by any of the trade and technical school systems which train the hand rather than the head, and which fail to take into account the impending changes which must inevitably demand an entirely different kind of skill from that formerly necessary, and which will as surely replace all excessive muscular effort as completely as the automobile is now displacing the horse for transport services.

PANORAMA OF THE OCOEE RIVER DEVELOPMENT, SHOWING THE FIRST DISCHARGE OF WATER OVER THE DAM, JANUARY, 1912

WATER-POWER DEVELOPMENT IN THE SOUTH

By J. A. Switzer

Professor Hydraulic Engineering, University of Tennessee

THE development of water-power on a large scale in the southern Appalachian region is proceeding at a rate little short of astounding. In no other part of the country is such rapid progress in this direction being made. How really new the hydro-electric industry in the Southern States is will be borne in upon us when we realize that in the Piedmont section of the Carolinas, now supplied with enormous electrical power by the Southern Power Company, it is but seventeen years since electrical transmismission was non-existent. That is to say, in 1895 the maximum distance over which power was transmitted was eight miles, and the voltage was but 5,500. And now the Southern Power Company, operating six hydroelectric plants and two auxiliary steam plants, sends 121,000 horse-power over 1,380 miles of transmission line at 50,000 and 100,000 volts. Covering a territory that stretches 200 miles from east to west and 150 miles from north to south, it furnishes the power that operates 156 cotton mills, lights the streets and stores and homes of 45 towns and villages, and operates the trolley cars of six more.

Among the latter it supplies the energy for the operation of the very extensive electric railway system of the Piedmont Traction Company in North and South Carolina, which is of particular interest because the voltage of 1,500 is the highest direct-current pressure ever used in this country for electric traction. This current is supplied through nine sub-stations, and, so far as possible, duplicate equipment

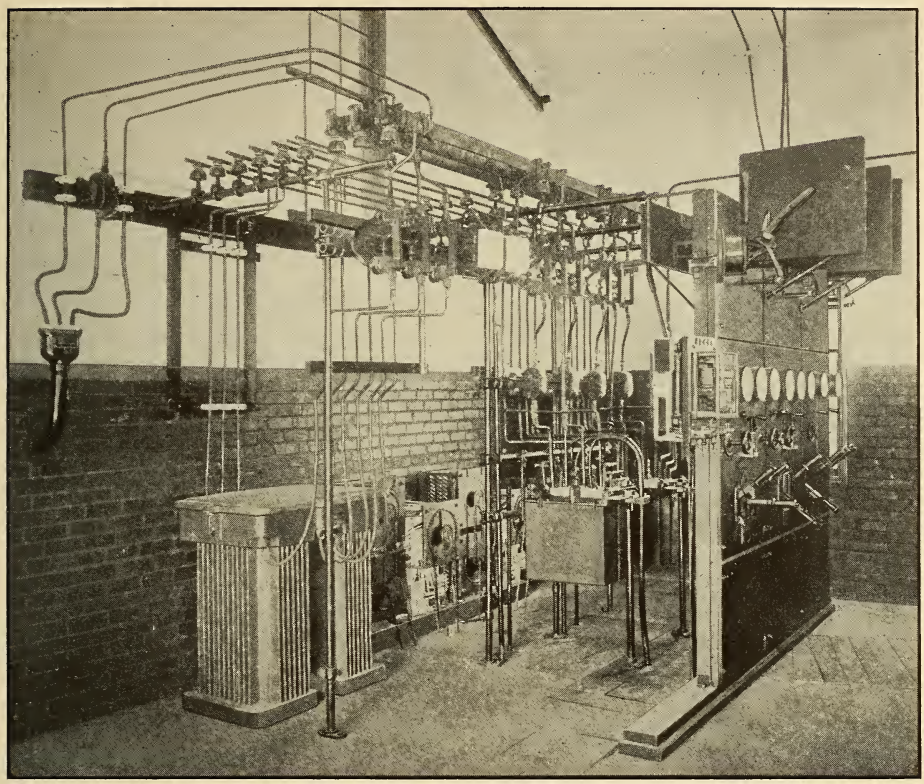
is used in all of the stations. The 1,500-volt direct-current is obtained by connecting two 750-volt direct-current generators in series.

All the equipment for these stations was furnished by the Westinghouse Electric and Manufacturing Company. In one of these stations the energy is taken from a 13,000-volt line, at another from a 44,000-volt line, which is fed through step-up transformers from a 2,200-volt line, and in all the other sub-stations energy is taken directly from the 2,200-volt lines; and in every case the voltage on the motors is 2,200. An interesting feature of these installations is that the circuit-breakers and knife-switches in the switchboards on the 1,500-volt circuits are arranged for remote hand control, the danger of accidents from high voltage flashes, therefore, being eliminated.

The experience of the Southern Power Company is interesting and illuminating. Beginning as a relatively small concern, it built a single power house on the Catawba river to develop 10,000 horse-power. This plant was completed in 1904, and the entire output was at once absorbed. So certain did the market for power appear to be that the company at once enlarged its scope, increased its capital to $10,000,000, secured control of a number of power sites on the Catawba River and the Broad, and began at once to construct its present elaborate system of power development and transmission. While it is true that, in some respects, the system of this company is the largest in the country, yet the demand for power within its territory is approximately four times the present capacity of the plant; the company owns seven more power sites, and when these are developed it will generate about 230,000 horse-power of primary and a large quantity of secondary power. Still this total will be something less than 15 per cent. of the latent water-power within this particular territory.

Commenting upon the rapidity with which these developments are proceeding, Mr. C. A. Mees, the designing engineer of the Southern

TYPICAL SUB-STATION, PIEDMONT TRACTION COMPANY. EQUIPMENT FURNISHED BY WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY



1,500-VOLT SWITCHBOARD EQUIPMENT SUB-STATIONS, PIEDMONT TRACTION COMPANY, ARRANGED FOR REMOTE HAND CONTROL, ELIMINATING DANGER OF ACCIDENTS. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Power Company, says: "Where in this territory in 1903 the operation of a short transmission line at 550 volts from power house to mill was an incident worthy of note, the 50 or 100-mile extension of a 44,000-volt line on the network of lines now being operated causes only casual mention."

While there were a few water-power plants of large size in operation prior to 1903, notably the municipal plant at Columbia, S. C. (14,000 horse-power), built in 1898, that at Athens, Ga., built in 1897, and that at Pelzer, S. C., built in 1896, none of these generated electricity for transmission, it may fairly be said that real hydroelectric development on the eastern slope of the Appalachians dates back only eight years; and developments exceeding a capacity of 15,000 horse-power but five years. During these five years the notable developments to come into operation are quite numerous, and it will suffice to mention, in addition to the Southern Power Company, only two: the plant of the Rockingham Power Company, on the Pee Dee River, in North Carolina, which since 1908 has developed 28,800 horse-power, and that of the Central Georgia Power Company, whose plant on the Ocmulgee River was completed last year. This plant has a present capacity of 16,000 horse-power and will ultimately develop 24,000.

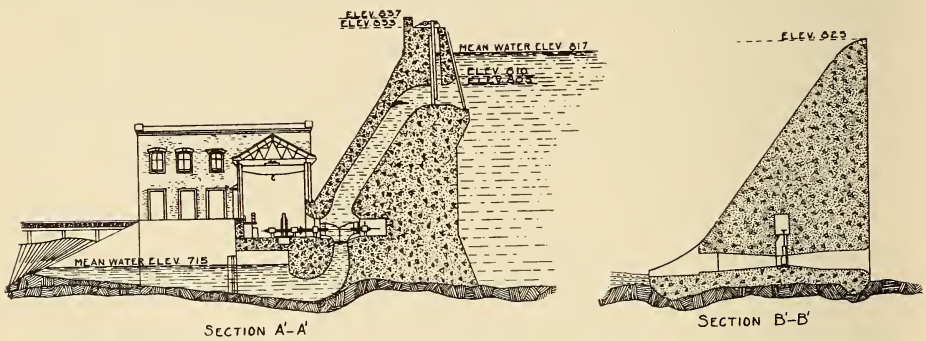
On the western slope of the mountains, developments are still more recent. In Alabama less than one per cent. of the latent water-powers have yet been utilized, and the largest

operating plants of which the writer is informed are two on the Tallapoosa River—that of the Montgomery Power Company, yielding 5,600 horse-power, and that of the Tallassee Falls Manufacturing Company, yielding 8,900.

Prior to January 1 of this year there were no hydroelectric plants in operation in the State of Tennessee. There were, however, 2,200 water-wheels, developing an aggregate of 95,000 horse-power, an average of but 43 horse-power per wheel. During the month of January two plants went into commission—the Watauga Power Company and the Eastern Tennessee Power Company.

The Watauga Power Company, located on the Watauga River, develops 4,800 horse-power, which is transmitted at 44,000 volts to Bristol, Tenn., 12 miles distant.

The plant of the Eastern Tennessee Power Company is located at Parksville, on the Ocoee River. The rights of the company cover the river from Parksville to Ducktown, a distance of 25 miles, in which an area of approximately 2,200 acres—nearly 3½ square miles—and contains 100,000 acre-feet of stored water. Of this stored water, only the top layer, so to speak, can be drawn upon for the production of power during the seasons of minimum stream flow. This layer extends from elevation 805 feet (above sea level) to elevation 825 feet (the elevation of the crest of the dam), and is hence 20 feet thick. It will contain about 31,000 acre-feet. Since the low tail-water elevation is 713 feet, the mean head which this storage water will have is about 103 feet; and the amount of power it would generate, if spread over a period of one month and allowed to discharge for twelve hours a day, would be 9,700 electrical horse-power. But the minimum stream flow of the river is about 350 cubic feet per second, and this water, discharging through the turbines for twenty-four hours per day, would generate about 3,500 electrical horse-power. Assuming, therefore, that extremely low water persists for one month of the



SECTION OF DAM AND POWER STATION, EASTERN TENNESSEE POWER COMPANY

length the river falls approximately 700 feet. Of this fall the plant now constructed utilizes 110 feet. The dam, 800 feet long, has an extreme height of 122 feet above mean tail-water elevation; it is of gravity section, built of cyclopean concrete. The pool extends from the dam upstream a distance of 8 miles, covers twelve, the plant would generate 3,500 horse-power during the night and 13,200 horse-power during the day. However, the year will doubtless prove to be exceptional, during which the stream flow will sink to so low a value as 350 second-feet, or even if it did, to remain so low for a period of thirty days. In order,

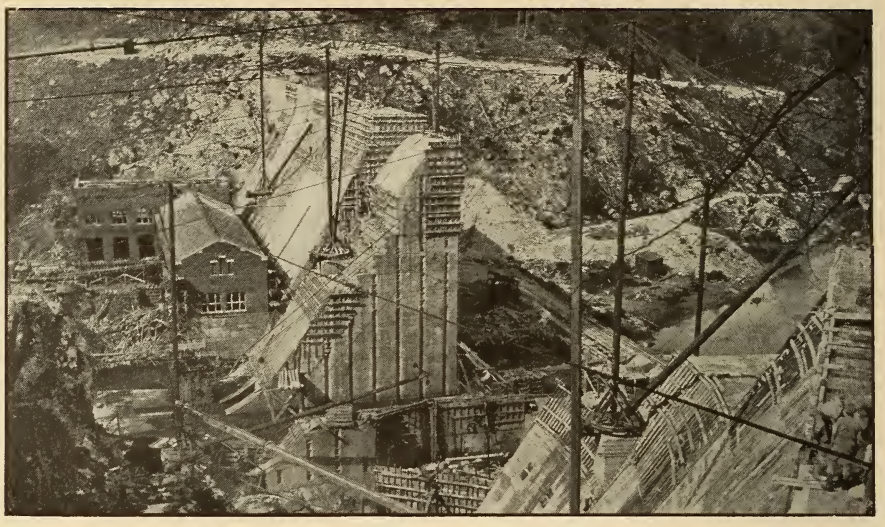
COFFERDAM FOR THE CONSTRUCTION OF THE PARKSVILLE POWER COMPANY, OCTOBER, 1910

however, to meet such a contingency, the company is provided with auxiliary steam power to the extent of 9,000 horse-power. Thus the minimum available horse-power will be about 20,000, and ordinarily there will be not less than 30,000 horse-power to be developed at the dam site.

Sectional views of the power house and the spillway of the dam are shown, one through the power house, the other through the spillway of the dam.

One is struck at once with the curious plan of the dam. It is safe to say that there is nowhere to be found another similar dam. Originally the plan was to build a dam straight across the river. But in preparing the foundation of the dam it was learned that a fault-plane existed in the bed-rock close to the south shore line. Unless provision were made to meet this condition, the fault would serve to weaken the dam. The original plan was therefore modified, and a horizontal arch constructed to carry the thrust of the water against the dam away from the region of the fault to the rock further to the south, where secure anchorage was to be had.

Returning to a consideration of the view showing sections, the section on the line *A' A'* shows the location of the penstocks, wholly within the dam itself, with the trash-rack guarding its entrance, and the headgate to be operated from the top of the dam, the twin horizontal turbines, each discharging inward through a quarter bend into the draft tube by which the water reaches the tail-race—the direct-connected generator. Within the dam, behind the turbines, a gallery or passageway is provided. This gives access to the rear bearings of the turbines, and also leads to the valves controlling the two permanent sluiceways which penetrate the dam within the spillway area. The details of these sluiceways are shown in the section on line *B' B'*. The plan drawing shows the location of the four units now installed and the place provided for a fifth unit for future extension. The turbines are 39 inches in diameter, of the "American" type (that is, inward and downward-flow turbines). Each pair will discharge about 640 cubic feet per second under a head of 110 feet, and will be capable of developing, under these conditions, approximately 6,000 horse-power. The turbines were made by the S. Morgan-Smith

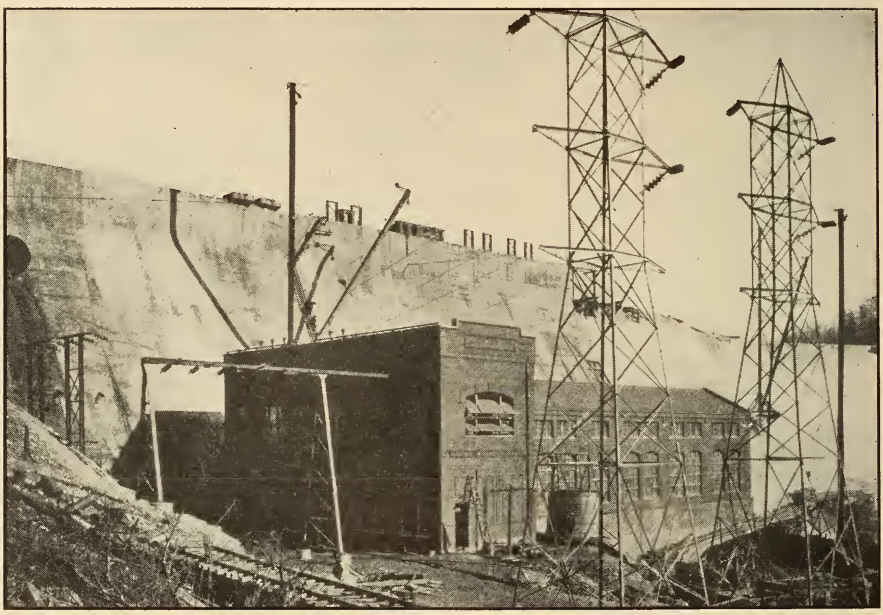


VIEW OF OCOEE RIVER PLANT DURING CONSTRUCTION, SEPTEMBER, 1911

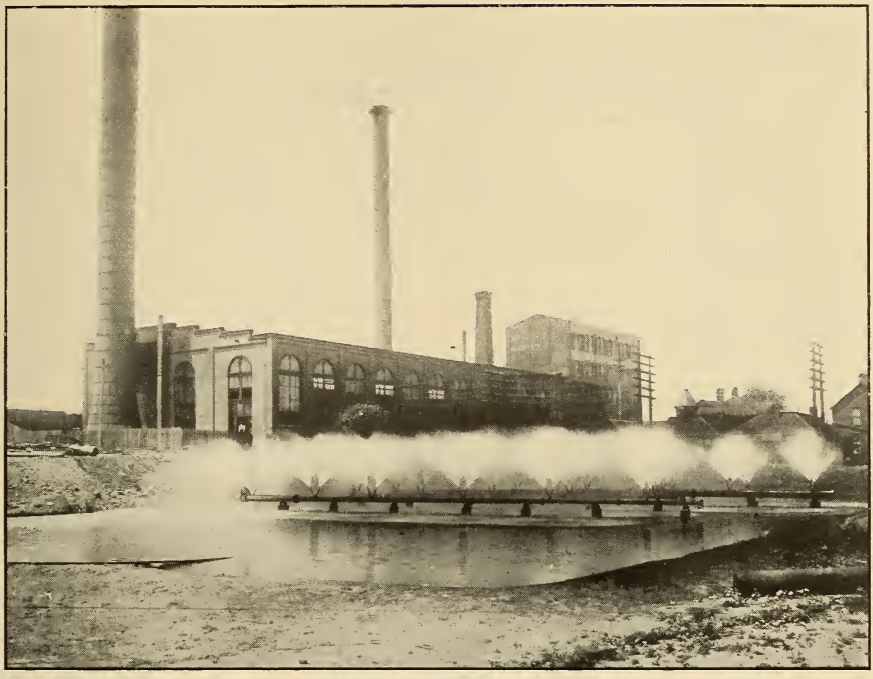
Company, of York, Pa., and the electrical equipment by the General Electric Company. The plant was built by the J. G. White Company, under the supervision of Mr. R. H. Anderson, resident engineer.

Power is transmitted over 215 miles of line at 66,000 volts to Knoxville on the north, Cleveland and Chattanooga, Tenn., on the west and Rome and Dalton, Ga., on the south. The traction system of Chattanooga is now operated from this source.

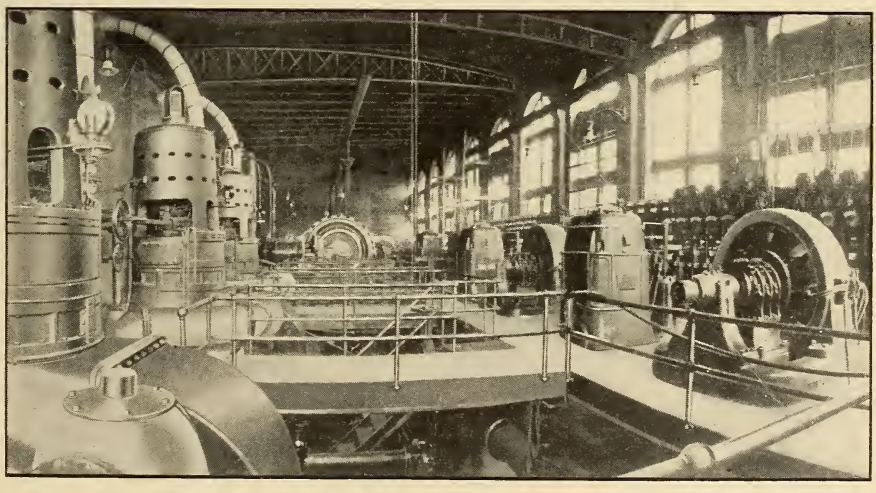
The upper project of the company



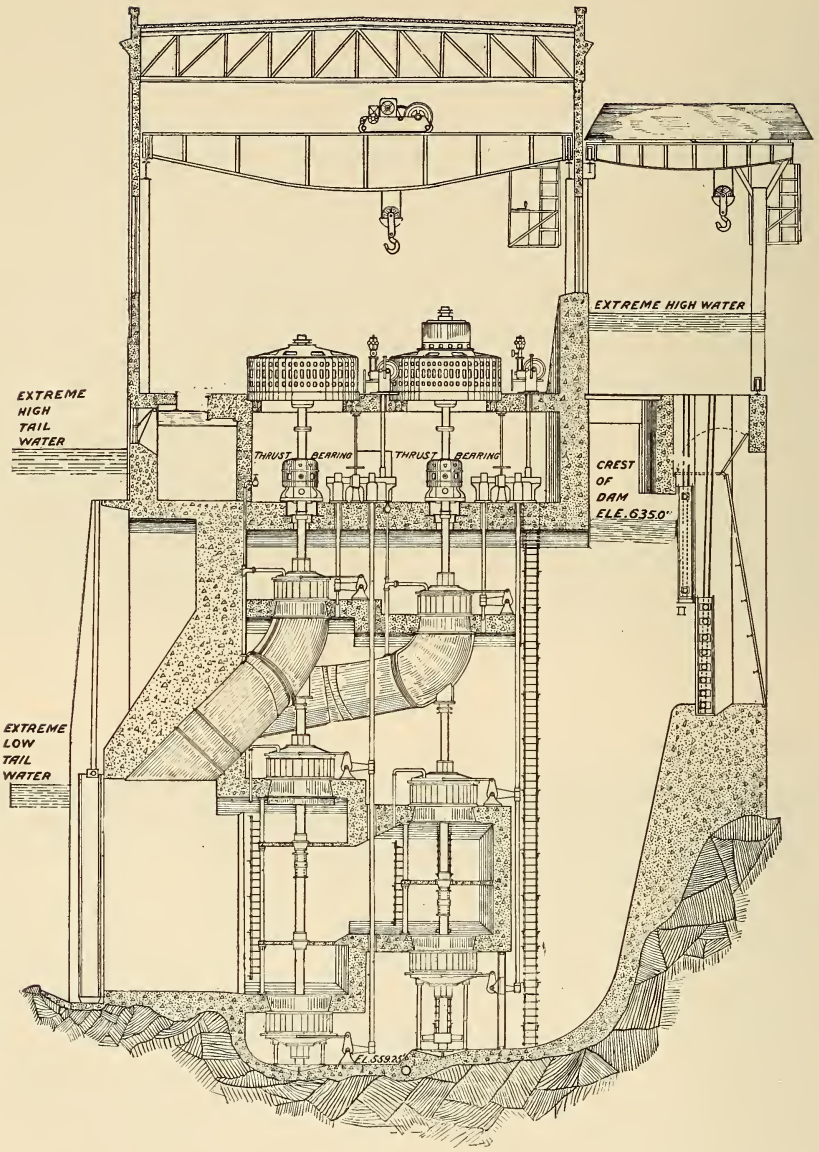
THE POWER HOUSE AND TRANSMISSION LINE. OCOEE RIVER POWER DEVELOPMENT



POWER HOUSE, CHATTANOOGA ELECTRIC COMPANY, CHATTANOOGA, TENN.



ELECTRIC EQUIPMENT FURNISHED BY GENERAL ELECTRIC COMPANY, CHATTANOOGA ELECTRIC COMPANY POWER HOUSE



ONE OF TEN UNITS OF THREE WHEELS, EACH DRIVING AN UMBRELLA TYPE GENERATOR IN THE PLANT OF THE CHATTANOOGA & TENNESSEE RIVER POWER COMPANY, GUILD, TENN. FURNISHED BY S. MORGAN-SMITH COMPANY

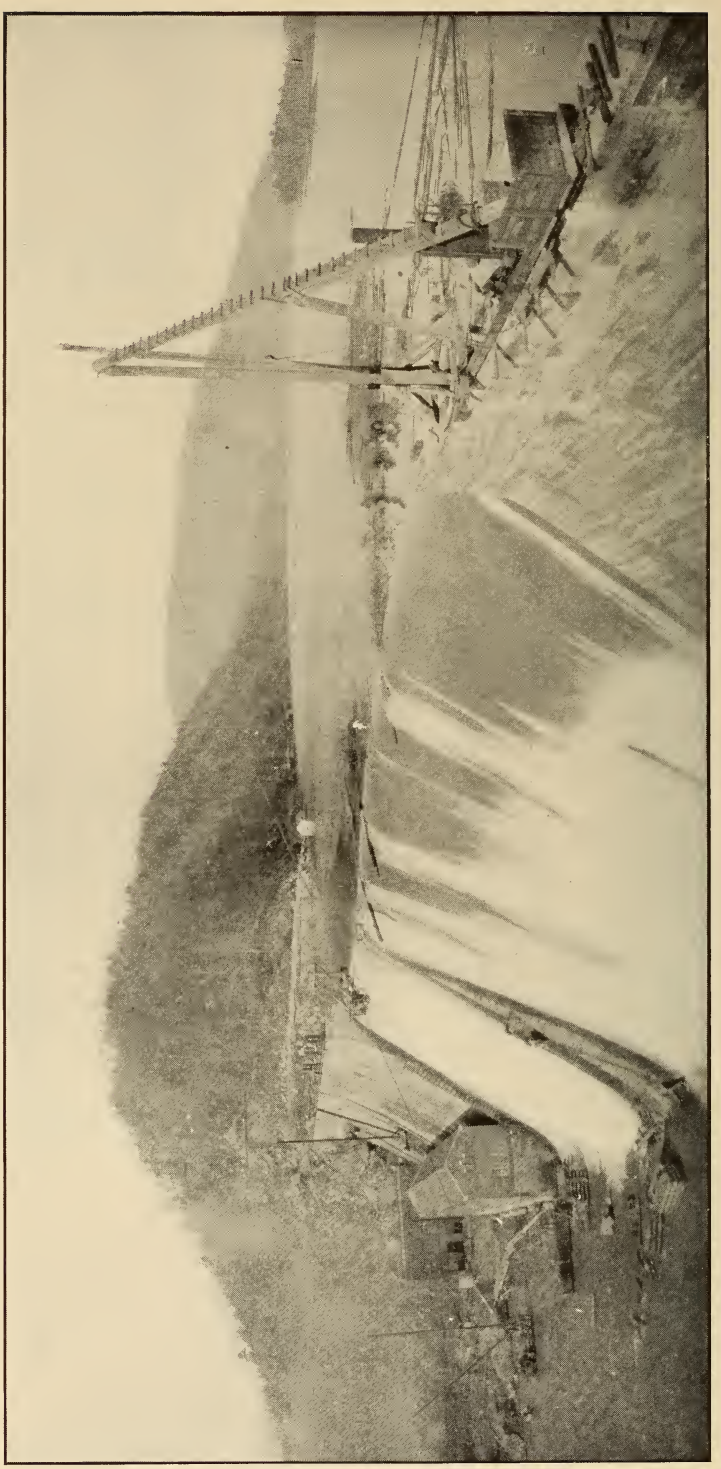
is not only larger, but exceedingly bold. A mile above slack water due to the lower dam, a second dam will be thrown across the river at a narrow gorge, creating a lake 16 miles long. From this the water will be diverted by means of a tunnel through Big Frog Mountain and a flume to the penstock six miles from the dam. By this means a head of 500 feet will be secured and about 60,000 horse-power rendered available, thus giving the company command of 90,000 horse-power. When built, this will probably be the highest head development east of the Rocky Mountains.

Very recently the holdings of this company, which include beside this power development, the street railway and lighting systems of Chattanooga and Cleveland, Tenn., and Rome, Ga., have been merged into two new companies of colossal proportions. The new companies are the Tennessee Railway, Light and Power Company, and the Tennessee Power Company, capitalized each for $50,000,000. The two companies, for legal reasons distinct, are in reality one concern. Their property includes in addition to all the above the Nashville Railway and Light Company, and last (but by no means least) another site for an important water-power development. This is the Great Falls power site, situated on Caney Fork, a tributary of the Cumberland River near Rock Island, Tenn., 90 miles east of Nashville. Here a head of 180 feet is available, and 80,000 horses await the touch of the engineer's lash to add their quota to the world's supply of electricity. The plans of the company contemplate the immediate development of this power, and the complete development of that yet remaining latent on the Ocoee River; also the extension of the transmission line from Ocoee, via Great Falls, to Nashville, thus tying all three hydroelectric plants and the steam auxiliaries into the one transmission system.

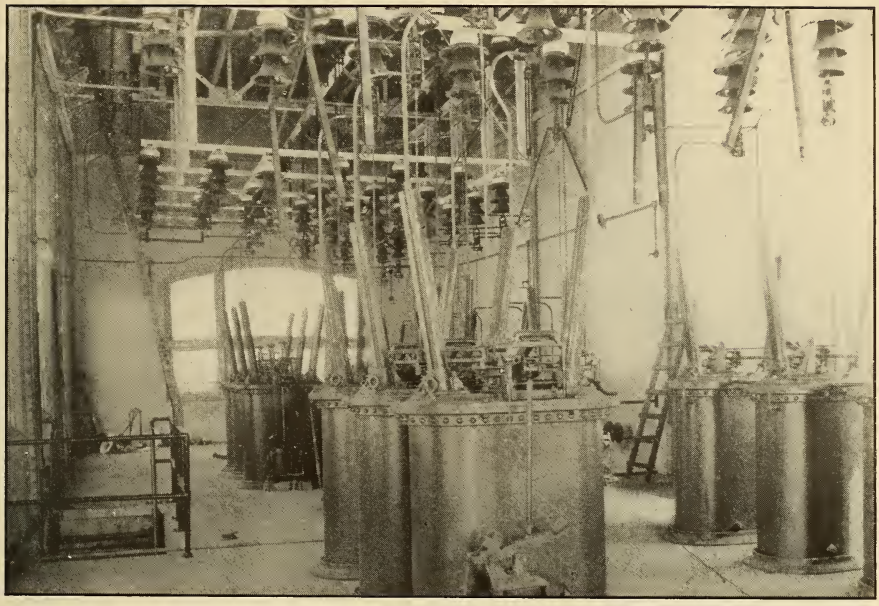
In many respects the most striking hydroelectric development in the south is that now nearing completion at Hale's Bar, in the Tennessee River. This is the project of the Chattanooga & Tennessee River Power Company, located thirteen miles below Chattanooga, in an air line and thirty-three miles below as the river winds.

The project was undertaken at the instance of the United States Government, and primarily for the purpose of improving navigation. Since 1830 the attention of the government has been directed to the improvement of the Tennessee River, and particularly to the improvement of the stretch of river from Chattanooga to Hale's Bar. The thirty-nine miles of the river, reaching from Chattanooga down to Shellmound, and known as the "Mountain Section," is, of the entire 652 miles of its length, the most dangerous to navigation. The physiography of the river here is quite different from that obtaining above and below. It is here that the river breaks through the Cumberland Mountains, and during its life it has cut a channel 1,000 feet deep. The river, therefore, partakes of the character of a rather large mountain stream. In the Mountain Section there are ten shoals, which make navigation hazardous at times of low water (and indeed impossible for boats drawing more than three feet); while at times of high water the swiftness of the current, with the accompanying eddies and whirlpools, due to the narrow and crooked channel, makes the passage of the river even more dangerous. It is the first instance in this country of a private corporation being permitted to throw a dam across a navigable river, and the first case in which the interests of the central government in improving navigation have been combined with those of such a corporation in the exploitation of a power site.

The dam will render available 58,800 horse-power, and, at the same time, will insure ideal slack-water navigation throughout the mountain



VIEW SHOWING THE SMOOTH FLOW OF WATER OVER SPILLWAY OF THE DAM ON THE OCOEE RIVER



OCOEE RIVER PLANT. THE 66,000-VOLT OIL SWITCHES

section. The pool will be thirty-eight miles long, completely submerging the shoals now existing, insuring a channel nowhere less than six feet deep at all times.

Construction was begun in 1905, and, according to all reasonable expectation, should have been completed some time ago. And so it would have been, except for the immense difficulties that were met in securing adequate foundation for the dam and power house. Preliminary exploration of the river bed by means of drilling had shown apparently solid rock under a blanket of sand and gravel from 8 to 10 feet thick. The bed-rock is Bangor limestone, lying in nearly level strata. In October, 1905, excavation was begun at the site of the power house, the foundation for which was carried down 75 feet below the original surface of the ground, 35 feet into the limestone rock. It was necessary to enclose the excavated area within a cofferdam on the river side. But although it was an easy matter to make the cofferdam watertight, it was found that great quantities of water spurted from fissures in the bed-rock itself. This condition proved to be very disconcerting.

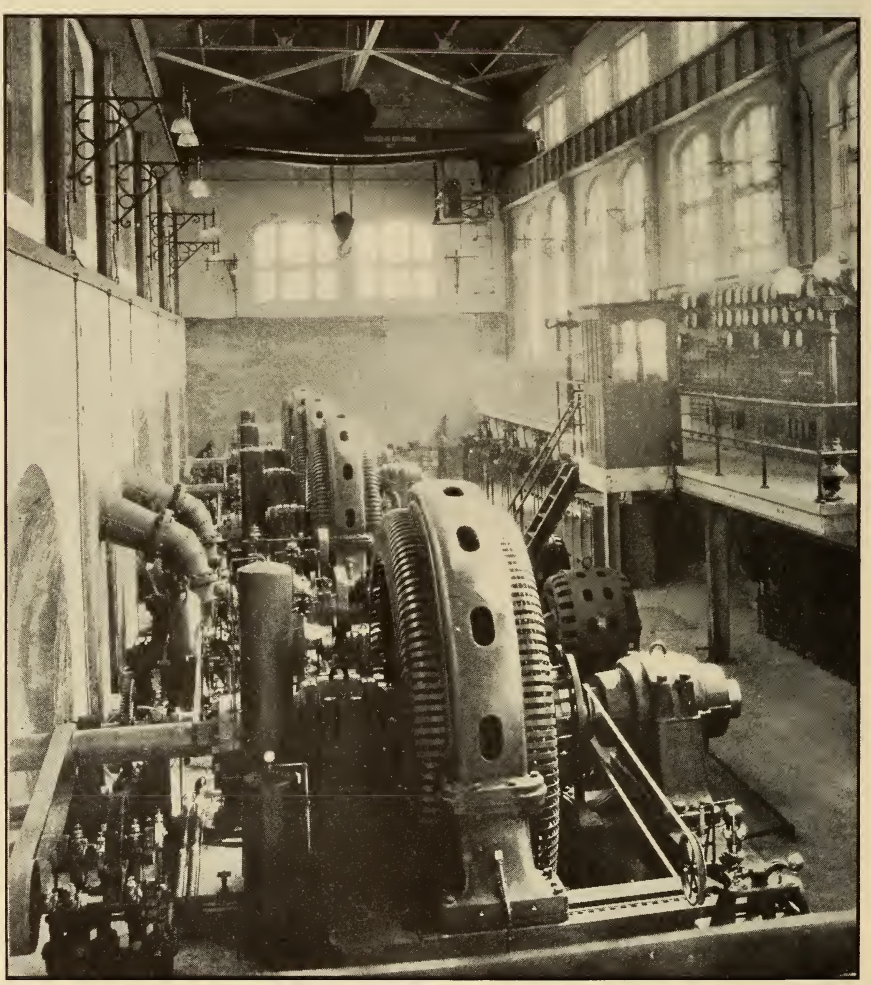
Before any concrete could be laid it was, of course, essential that these fissures should be closed. To accomplish this, well-drilling apparatus was used, and numerous 6-inch holes were drilled to a depth varying from 30 to 50 feet. Pipes were then sealed into the upper ends of the holes and cement was forced under pressure into them until they would take no more, thus "grouting" the fissures and effectively sealing them. This process was a slow and difficult one, and for the power-house foundation alone approximately 25,000 bags of cement were thus used.

When it came to building the dam itself the same conditions were encountered. When a section was cofferdammed and the cofferdam was unwatered, water gushed up through the bottom. In one instance the course of the water from one cofferdam standing full of water to another that had been emptied was

traced by the interesting device of coloring the water in the former with potassium permanganate. The fountains in the second cofferdam straightway showed the purple color. This connection was fully grouted. Some of the fissures discharged over 20,000,000 gallons a day, and all of this water had, of course, to be handled by pumps until the fissures could be closed by grouting. It should be explained that before beginning the process of grouting, after the pipes had been set, it was necessary to refill the cofferdam with water, and, in fact, to maintain the level within it somewhat above that on the outside, thus overcoming the tendency of water to rise in the pipes and oppose the flow of the cement to the bottom and out into the ramifications of crevices.

At the present time, although the foundation for the dam is not yet all in place, over 100,000 sacks of cement have thus been used in closing these subterranean waterways.

Beginning at the power-house end, the foundation of the dam has now been built for a distance of about 400 feet, and sections about 30 feet long, separated by intervals 20 feet



THE GENERATOR ROOM IN THE OCOEE RIVER POWER HOUSE

MAP OF "MOUNTAIN SECTION" OF TENNESSEE RIVER.

MAP SHOWING LOCATION OF HALES BAR DAM, WITH REFERENCE TO CHATTANOOGA

HALES BAR POWER HOUSE, SEEN FROM TAILRACE

HALES BAR POWER HOUSE. LATER VIEW. THE STOPLOGS CLOSING THE BAYS ARE TEMPORARY

VIEW OF UPSTREAM FACE OF HALES BAR DAM, SHOWING THE TEMPORARY GAPS LEFT FOR THE FLOW OF THE RIVER

LOOKING WEST ACROSS THE RIVER FROM THE END OF THE POWER HOUSE, NOVEMBER 1, 1911

AN IMAGINATIVE VIEW OF THE HALES BAR DAM, POWER HOUSE AND LOCK, AS THEY WILL APPEAR WHEN FINISHED

in length, have been built to the crest. These completed sections give the impression of piers, with the water flowing between. The entire dam will thus be built—that is, foundation will be brought up to about 2 feet above low-water level and blocks of the full height will alternate with openings to act temporarily as sluiceways. Then the openings will be successively closed by steel curtains, and concrete will be built up about 2 feet at a time and the curtains removed. When all the gaps have thus been raised 2 feet, the process will be repeated until all are 2 feet further toward completion. In this way the flow of water will be subdivided between the many openings, the water being gradually backed up as the process continues.

(To be concluded.)

ONE CAUSE OF HIGH PRICES AND ITS REMEDY

By H. Washburn

WISE, economical management, which is what the term "scientific management" should mean, is based on doing the right thing the right way, at the right time, in the right place. In this way articles of standard merit are produced and marketed at the lowest possible expenditure of money, time and labour, without sacrifice in quality or quantity, but with enhancement of both.

In manufacturing the principle is applied to the processes by which the articles are produced, to the purchase of raw material, to its handling and care from the time of purchase to that when it becomes a finished product, each step being watched with the idea constantly in mind of producing the article in the highest state of perfection at the lowest possible cost consistent with standard quality.

Economical production, while essential to the success of wise management, is no more so than economical selling methods. No matter how carefully the former is watched, if the latter are not correct neither the owner, the employees, nor the consumers of the article produced will obtain the benefit of the lowest possible selling price.

Methods of marketing are equally as important as those of production.

Critics of "scientific management" state: "No matter how sugar-coated it may be, it is designed more often to benefit the owner than the worker and consumer."

Such, however, is not always the case: A fine instance of wise economical management, for example, is that of the Postal Life Insurance Company of New York, in its method of doing business without middlemen, through which it is able to save the policyholder an average of 45 per cent. of the first year's premium, 9½ per cent. in subsequent years, and yet pay, in addition, the usual policy dividends, ranging up to 20 per cent. of the annual premium, all combined with absolute safety.

The dictionary gives the definitions of science as "knowledge"—"a liberal art." Certainly a company whose selling policy combines both definitions in one and shows a knowledge of the art of being "liberal" to its policyholders furnishes an example of true "scientific management."

This company is able to do this, because it is wise enough to see that the ordinary methods of selling life insurance, as pursued by other companies, are not economical. It therefore cuts out all middlemen; it dispenses with agents, and thus saves for the purchaser of insurance the money ordinarily paid them—paid to these agents nominally by the other companies, but really by their policyholders, through higher premiums.

"Handing it along" is human nature, and the insurance company that has to pay agents' commissions, you may be sure, includes these commissions when making up the selling price of its insurance.

Economical management means three important things—a standard article of a high degree of merit, produced at the lowest possible cost, and sold at the lowest possible price consistent with its true merit; and any form of management that accomplishes these things is along the line of genuine public service.

INANIMATE CHARACTER

By O. D. Lee

NO higher compliment can be paid a man than to say that he can be depended upon; that no matter what the circumstances may be, what unforeseen obstacles have to be met with and overcome, he can be counted upon to perform the work intrusted to him in a satisfactory manner. Men possessing this sort of character are always in demand; there can't be too many of them to fill the positions calling for them, and it is upon this trait that the foundations of all great successes have been built.

This being true of mankind, how much more so of inanimate things. No matter if it is men or machinery; reliability, quality and character are needed and demanded.

Wonderful as they are, aeroplanes are at present of little practical value, for the reason that as yet absolute dependence cannot be placed in them; no one knows how they will act under any and all conditions. That this character of reliability, which they now lack, will eventually be given them, no one doubts; but until it is installed in them their lack of it greatly limits their usefulness.

The adding machine, the cash register, must give correct totals, not only at one time, but always, and so on through all branches of mechanical devices.

One firm that for more than fifty years has kept this word character always before them, whose present great business is not of mushroom growth, but a growth like the oak tree, which develops from the acorn, their trade-mark; one of sturdiness, strength, reliability and character, is the well-known Cameron Steam Pump Works of New York.

Owing to the adherence to this policy of character in their product, Cameron pumps are known and used throughout the world. In every great engineering work in which the problem of pumping enters, there one finds a Cameron pump working and giving every satisfaction in the duties it is called upon to perform.

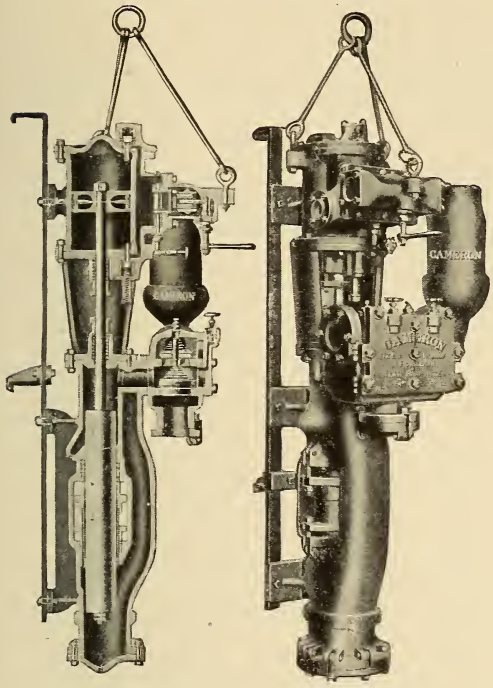
Perhaps no better illustration of the character of these pumps can be given than in their sinking pumps, both for mine and contractors' use. This sinking pump has fewer working parts than any other pump, which has been brought about by a process of careful elimination covering fifty years of intelligent effort, with the result that they have produced a pump that gives the best service, even under the unusually hard conditions that prevail in engineering work.

In the construction work of the Hudson Companies tunnel, in New York, this pump was largely used, and Mr. Charles M. Jacobs, the chief engineer of that work, states that, after thirty-four years of use of Cameron pumps, he has never found them to fail to perform their full duty.

In the construction work of the Catskill Aqueduct they are largely used, while for mine work, under the hardest conditions, and no matter how gritty the water may be, Cameron pumps deliver the water steadily and constantly without any stops for repairs, and have been found abso-

lutely dependable at all times and under all conditions.

The Cameron sinking pump has



A PUMP OF CHARACTER
CAMERON VERTICAL PLUNGER PUMP

no outside valve gear, arms or levers to be bent or broken off, while the design of its exhaust cut-off allows it to be operated with an irregular or intermittent supply of water or when the water fails entirely, and this not only without danger of the piston striking the heads, but without injury to the valves.

Another favourable feature, which close attention to character has provided for in this pump, is fitting the glands with hinged bolts, thus allowing the pump to be packed from the outside easily and quickly.

The priming valve of this pump deserves special mention, as it is designed to obviate the objections which pertain to other devices of this character. For instance, it avoids the precipitation of the weight of the discharge column into the suction hose, which might become ruptured by the undue strain, and prevents the accumulation of dirt or sediment behind it, which would result in its becoming locked and immovable.

The sand pocket at the top of the upper stuffing box is also an important improvement, for by its use the sand and grit will not settle around the plunger and allow it to become scored. These features are distinguishing points of this pump.

The above is only one out of many examples of modern practice which could be given to illustrate the present tendency to require reliability. Purchasers have learned to demand it, and manufacturers understand that the day has passed when either a human being or a machine can succeed that does not possess character.

No longer can any article, like the Frenchman's razors, be built merely to sell; it must possess merit and reliability.

It matters not how talented, how learned a man may be; if he does not possess character and absolute reliability he is not wanted. No matter what the claim may be for any machine or device, no mattter how attractive it may be, how well it works under ideal conditions, the question is surely put: Will it "stand up to its work"; will it meet trying conditions and still prove reliable? In a word, does it possess character, that grandest of all things in both the animate and inanimate?

F. C. Lincoln, S. B. Massachusetts Institute of Technology 1909, E. M. New Mexico School of Mines 1904, A. M., Columbia University 1906, Ph.D. 1911, for three years Professor of Geology and Metallurgy at the New Mexico School of Mines, for three years Professor of Geology at the Montana State School of Mines, and for the past year in practice in New York City as Consulting Mining Engineer, has been appointed Associate in Mining Engineering of the College of Engineering of the University of Illinois.

THE TYPEWRITER OPERATOR AND HER NERVES

[The following article, which appeared in a recent number of *Habits*, is worthy of reprinting, indicating, as it does, the trend of manufacturers at the present time to do all they can to conserve human strength and lighten the strain, both physical and mental, of modern business demands. While the conservation and development of natural resources is very important, hand in hand with such movement goes the equally important question of the conservation of the human resources of brain, nerve and muscle, and all improvements in this direction will prove, not only of great value to the present generation, but to future ones, and are a step in the right direction.—THE EDITOR.]

One of the greatest evils of modern business methods is the bad effect they have upon the health of those employed. Although there is no doubt that the neuropathic constitution has existed in all ages, yet distinctive types of nervous impairment like those of to-day were hardly known in the past. Among the most frequent nervous ailments is one known as writers' paralysis. Much may be said in favour of the use of the typewriter in lieu of the pen as a relief to and a preventive of nervous troubles of this character, but there can be no doubt that the constant use of hard-running and highly-tensioned typewriters is itself also productive of derangements of the nervous system of a most serious character.

Neurasthenia may be defined as an abnormal susceptibility to fatigue after mental or bodily exertion. A large percentage of the cases of this derangement is the direct result of the use of the typewriter. It is a fact not generally recognized by employers that the constant use of the typewriter is not only a mental strain, but also a severe physical strain. The manipulation of the typewriter in a busy office, constantly pounding the keys hour after hour and day after day many thousands of times every day, subjects one to physical strain. The faster the machine is operated and the greater the resistance of the keys and other mechanism in overcoming friction and spring tensions, the severer the shock, both with respect to the impact of the fingers against the keys and of the typebars as they strike the paper as it is held against the platen. Here are all the conditions necessary to produce nervous breakdown—mental strain plus physical strain—provided such work is continued for any great length of time, and particularly to those who are obliged to guard against such ailments.

Recognizing the faults of the old-time typewriters, manufacturers are sparing no efforts to mitigate them. In their efforts to relieve the operator of all unnecessary physical strain, various expedients have been devised. The only satisfactory solution of this problem is to be found in the Monarch visible typewriter, wherein the typebars are caused to start very slowly with a minimum amount of force and then swing to printing position with an accelerated motion. In the Monarch typewriter the key levers operate upon the typebars with a variable leverage. By this means the inertia of the typebar as it lies at rest is overcome and set in motion by a very long leverage, which gives the easy start and light touch; and thereafter, as the leverage shortens, the speed of the typebar is gradually increased without the increase of muscular effort, and the typebar strikes the paper with the required force. At the striking

(Continued on page 89.)

A SUCCESSFUL FACTORY FIRE DRILL TEST

THREE THOUSAND PERSONS, MOSTLY WOMEN, SAFELY OUT OF BUILDING IN FOUR MINUTES

By H. W. Francis

TWO interesting demonstrations showing the practical value of proper fire drills in factories were given under the direction of Mr. H. F. J. Porter, the well-known fire prevention expert and industrial engineer, during the sessions of the Wagner-Smith New York State Factory Investigating Commission in New York City.

On December 18 last, during the morning session, Mr. Porter explained the difference between the "stair" drill and a "wall" drill, and then, under Mr. Porter's direction, the Commission went to a cigar factory at Second avenue and Fifty-fourth street, New York, in which 3,000 persons were employed, to witness an exhibition "stair fire drill."

The fire drill in this factory was installed by Mr. Porter about six years ago, and as there were not sufficient exit facilities to allow the occupants of the building to leave it quickly in case of emergency, Mr. Porter had to install a separate stairway for each floor. By this arrangement the stream of people from one floor does not come in collision with the stream of people from any of the other floors.

No preparation for this special drill had been made, and no warning had been given to anyone in the factory. No one knew of the visit of the Commission save the heads of the concern. The fire alarm was rung from the office of the manager of the concern shortly after the luncheon hour, and immediately, without the slightest confusion, stations were manned and the operation of clearing the building commenced. In less than five minutes the 3,000 employees, mostly women, were safely out of the building.

All the members of the Commission expressed themselves as well pleased with the demonstration, which clearly showed what can be done in the direction of emptying an old, inflammable building by means of a certain type of fire drill. This type of fire drill was described in this magazine in August, 1905.

After viewing this drill, Mr. Porter showed the Commission a "wall drill" at a sheet and blanket factory at Fourteenth street and Avenue C, where about the same number of girls are employed. One-half of these empty one side of the building in less than a minute by passing through doorways in a fire wall, which extends from cellar to roof, bisecting the building. Drills of this kind in so-called "bisectional" buildings were described in this magazine in June, 1911. Mr. Porter claims that the "stair" type of fire drill is dangerous and obsolete, and, as in use in the public schools, is a waste of the time of the scholars and teachers and of the public money. When architects learn how to design their buildings, utilizing the fire wall as a distinct principle in architecture, drills will not be required to educate their occupants how to get out of them.

Mr. Porter is the originator of factory fire drills, and has met with great success in this line of work, which is only one detail of his extensive work in connection with industrial betterment, on which subject he has been a constant contributor to this magazine during the past fifteen years.

Picking Things Up

WHEN machinery was nrst applied to the service of man it was used principally for the simplest and, at the same time, the longest operations. The first steam engines were used to pump the water out of mines; these were followed by winding engines to hoist the mineral, and by railways over which it was hauled long distances. The intermediate operations were still regarded as work demanding the labour of men's hands and the exertions of human muscle. The coal was cut by hand, loaded by hand into cars, which were propelled underground either by men or by animal power. When the mineral reached the surface it was again transferred by human labour to the railway cars, and a similar performance took place upon its arrival at its destination.

It is only within comparatively recent times that the effort of the engineer has been directed toward the replacement of man's arms by mechanical devices for picking things up and putting them where necessary in the course of transport to their ultimate destination. Now, however, this portion of the operation is being more and more effected by machinery.

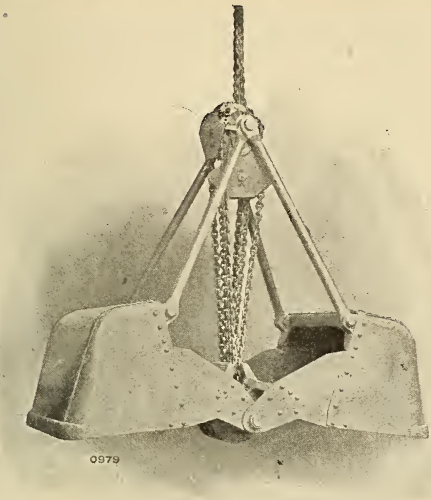
Automatic loading and dump apparatus for cars, lifting magnets for rails, pig iron and similar material, grab buckets for coal, ore and all kinds of loose granular substances—these are the devices which are enabling the intermediate operations of handling to be performed without the aid of human muscle.

It is said that the material from which a steel rail is made is untouched by human hand from the time the iron ore is dug from the bank by steam shovel to the point where the finished rail is lifted on the shipping car by electric crane and magnet.

Dug by power shovel and dropped into the car, the ore is dumped into the hold of the vessel, only to be lifted by grab bucket into the bin, where it is again delivered to car and to furnace hoist. The molten product of the blast furnace goes directly to the converter, and the steel ingot passes, by way of the soaking pit, to the rolling mill, only to emerge as the finished rail.

This is but a single example of the manner in which the intermediate operations of picking things up between trips have been replaced by mechanical devices, and even a cursory examination of many other departments of industry would reveal applications of such devices as the grab bucket, which, with wide-open scoops, gathers up and holds a volume of material which would formerly have required much laborious shoveling.

All such devices for the performance of laborious work are tending toward that continuity of operation which is so essential to the attainment of maximum efficiency. Absolute continuity cannot be attained in operations which are in themselves discontinuous, but the influences of interruption are both fewer and of briefer duration with the extending use of mechanical handling appliances than with the employment of human labour. In addition, the labour which is required must be of a higher order of intelligence, capable rather of directing the operations of power-driven machinery than of doing the actual work. It is in this respect especially that the use of machinery for the relief of mankind from exhausting and brutalizing effort is to be encouraged, since the whole tendency is toward the development of opportunity of activities of a higher kind and for the use of intelligence rather than muscle. Science has shown that human energy cannot possibly compare with manufactured power, so far as commercial efficiency is concerned, while experience is revealing the extent to which the development of mechanical appliances is aiding to relieve man from physical burdens.



HUNT GRAB BUCKET

For Handling Coal, Ore, Broken Stone, etc.

Note the width of the opening of the shovel

THESE BUCKETS TAKE A FULL LOAD QUICKLY AND EASILY IN ANY POSITION, NO MATTER IF DROPPED SUDDENLY OR IF LOWERED GENTLY.

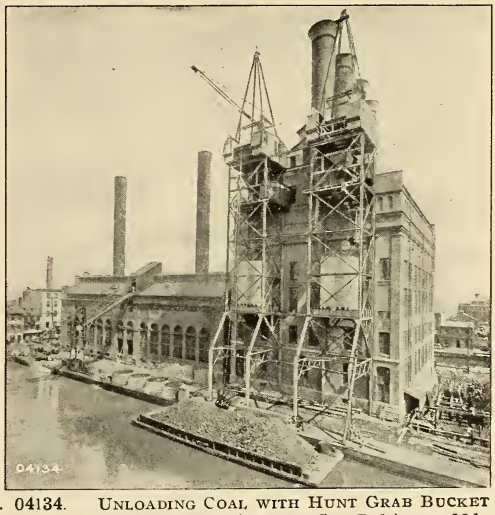
IT is the only bucket on the market that will dig splint coal satisfactorily and is the best bucket for digging lumpy run of mine coals.

They are of unusually heavy and strong construction.

The main bearings are brass-bushed and when worn a new bushing will bring the bucket back to its original effectiveness.

Regular sizes are kept in stock and can be shipped promptly:

42 Cubic Feet
104 Cubic Feet
208 Cubic Feet



No. 04134. UNLOADING COAL WITH HUNT GRAB BUCKET AT THE UNITED RAILWAYS & ELECTRIC CO., Baltimore, Md. Height the coal is hoisted, 151 feet.

These capacities are figured liquid full. Bulletin F. I. sent on request.

C. W. HUNT COMPANY

(Established 1872)

OFFICE, 45 BROADWAY, NEW YORK

Works, West New Brighton, N. Y.

CHICAGO: 1616 Fisher Building **SAN FRANCISCO, 865 Monadnock Building**
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Matter Out of Place

A WELL-KNOWN definition of dirt is that it is "matter out of place," and in many instances this is doubtless correct. One of the greatest difficulties against which the steam engineer has to contend lies in the fact that he has to generate steam from water which is far from being pure and clean, and which contains solid substances, both in suspension and solution—substances which cannot pass out of the boiler with the steam, but which remain and accumulate until the efficiency and safety of the steam plant are materially reduced.

These impurities in boiler feed water have to be encountered at some point in the passage from the source of water supply to the delivery of the pure steam to the engine, and, whether he will or no, the operative engineer must do something with them or they will ultimately do things with him. In general, the impurities found in solution in boiler feed water are calcium salts, the carbonate or the sulphate, these having been dissolved from the strata through which the original rain water has passed on its way through the crust of the earth to the springs, rills and rivers from which it is taken. The material in suspension is usually earthy matter, clay, etc., washed out by the force of the stream, and so finely divided that it remains suspended unless ample time of quiet is given to permit it to be settled out. All of these substances have their proper uses, and may be considered as unobjectionable in the right places.

In boiler feed water, however, they are certainly "matter out of place." Nevertheless, it is not uncommon to find steam plants in which these unwelcome interlopers are allowed to remain until the last moment and find themselves entrapped in the boiler, where the water which has carried them along so effectively is rapidly converted into steam, leaving them behind in the form of hard and soft scale and as mud. Certainly under such circumstances they form matter very much out of place.

The extent to which this state of affairs actually exists may be inferred from the manner in which apparatus and methods for cleaning boilers are in use. In many steam plants the operation of cleaning the inside of the boilers forms a regular part of the routine, and a sufficient steam generating capacity is provided to permit a certain portion to be out of service for sufficient time to permit the periodical cleaning to be done. Quantities of scale are removed, either by hand or power-driven tools, from surfaces which should never have anything but water in contact with them. Solid matter, once in solution in water from which it might readily have been precipitated, has been allowed to be deposited at the very point where it would do the most harm, and whence its removal would be most difficult and expensive.

A steam boiler is supposed to be an apparatus for the conversion of water into steam, but in too many instances this is only one of its actual functions, and it is also a device for the accumulation of scale and mud.

Since all the facts in connection with the removal of impurities in boiler feed water are well known, there is no excuse for the mismanagement which makes the boiler the receptacle for such impurities. They are out of place in the boiler, but it is not difficult to provide an appointed place in which they may be effectively separated and completely deposited—a place in which they can do no harm and from which they may be drawn off and removed at a minimum of expense and no delay.

The installation of proper water-softening and purifying apparatus, therefore, should form an essential element in every well-designed steam power plant, not only because of the influence which pure feed water has upon the life of the boilers, but also upon the efficiency of the whole.

This Apparatus Will Save Fuel, Save Your Boilers and Save Work

One concern who installed a Dodge "Eureka" Water Softener and Purifier reports a saving in fuel of 12%—another 7%—others from 10 to 20%. In our own plant, where we have a "Eureka" in operation, we find it cuts down our fuel bills about 15%. The saving depends on conditions. And in addition, a vast amount of work and of wear and tear on boiler room equipment is avoided.

This "Eureka" Water Softener and Purifier solves the most difficult problem of economical power plant operation—the elimination of boiler scale.

The bad effects of scale in boilers are well known—explosions, loss of heat transmission, and attendant evils. But it is hard to appreciate its prevalence without investigation. Our experience convinces us that there is scarcely a steam boiler in this country, fed with natural water, which is free from scale accumulation.

And the logical way to prevent scale is to provide the boilers with pure soft feed water.

The DODGE "Eureka" Water Softener and Purifier

automatically treats and purifies the raw water before it enters the boilers, eliminating from it all scale-forming matter. This does away with the use of expensive "dope" and gradually removes all incrustation that may be in the boilers when the "Eureka" is first installed.

It prevents the formation of new scale, thus keeping the boiler tubes clean, so they will not pit, corrode or explode, and greatly prolongs the life of the boilers. It will take less fuel and heat to turn the water into steam when the heat does not have to penetrate a thick coating of scale. And there will be no need of cleaning the boilers every few days.

This is what the "Eureka" machine is doing at hundreds of power plants throughout the country. Doing it automatically, with almost no attendance and only about a half-hour's attention each day. And at pratically no cost, because the saving made by the "Eureka" much more than offsets all the expense connected with it.

If you will send us a sample of the boiler feed water you are now using, we will analyze it and tell you just what the "Eureka" machine will do for you, what the cost will be, and how long it will take the apparatus to pay for itself.

Or, let us send you our Bulletin C-117, "The Water Question." It tells all about the "Eureka" Water Softener and Purifier—how it operates and what it does. Act today—take this first step toward greater power plant economy—Now.

Dodge Manufacturing Company - Mishawaka, Ind.

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Agencies in other Leading Trade Centers.

Air Engineering

WHY have we not air engineers as well as electric engineers and the others? Compressed air and the air compressor would seem to be sure of constant and of continually extending employment, as long as industry and civilization continue. The conditions of air employment already have almost unlimited range. Air is required, according to the uses to which it is to be put, at all pressures, from that which is measured by tenths of an inch of water, up to thousands of pounds to the square inch; and in all quantities or volumes, from that sufficient to spray perfumery upon a lady's handkerchief up to the blowing of a blast furnace.

The requirements in air compressing apparatus have, by a large industrial automatism, differentiated or separated themselves until now we have immense manufacturing establishments devoted each exclusively to one of at least four different and distinct classes of air compressing apparatus. There are manufacturers of fan blowers, of "pressure" blowers, of blowing engines, and air compressors distinctively so called, each producing its specialty exclusively.

By far the most numerous and, as would seem, the most important of these several apparatus, is the air compressor, whatever the drive of it may be, which has air compressing cylinders with reciprocating pistons, so that compressors of this type must apparently, for a long time to come, have the first place in our considerations of efficiency and of applicability to the different requirements which are developed.

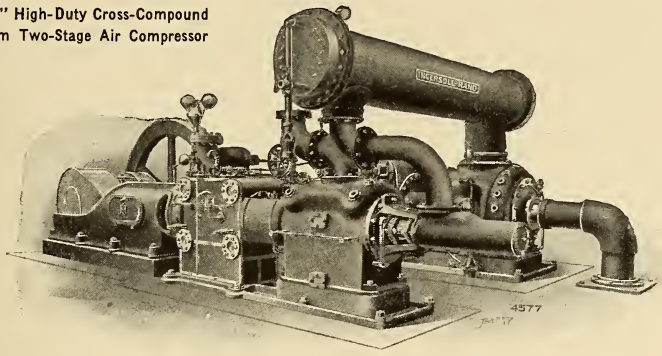
Although the operating of a water pump and of an air compressor may, at first thought, seem quite similar, the conditions and requirements really are different all the way through, and the problem of the latter is vastly more complex and difficult. The elasticity alone of the air changes the character of the work at the beginning of it, and the resulting transfers or transformations of opposing pressures are only a small part of it. Questions of temperature, of humidity, of velocities of flow each furnish their factors, and then the matter of storage and of adjusting the air output to the consumption demand to be provided for.

It is no longer sufficient in any line of manufacture to produce a machine which will actually work and which can be guaranteed to keep on working, although these are essential requirements. The precise manner and measure of its working in excess or that may determine its acceptance or rejection. The working must be as economical of power as possible, or must best satisfy certain other conditions of service which are often quite imperative. The fewer the sacrifices of essentials involved and the more satisfying the unavoidable complications, the more desirable the apparatus.

In the variety of machines required, both as to size or actual capacity and also as to the relative capacities of the power-developing and the power-applying elements, it must be evident that the works of large capacity has a great advantage, and one which it may legitimately claim for itself.

Not only is the most satisfactory air compressor to be expectantly sought in the older and larger establishments, but here also should be found the larger experience, and, as a consequence, the most competent advice as to air employment. One cannot be a qualified designer and builder of an air compressor, or of anything else, without following it out into the field of its employment to see how it does its work and how its working might be improved, or, in some cases, how changes in the methods of using the air might be made for mutual advantage, so that in this way the compressor man may be a desirable adviser for the rock drill man, the pneumatic tool man, the tunnel-driver, and the other air workers.

Class "OC-3" High-Duty Cross-Compound Corliss Steam Two-Stage Air Compressor



A Saving of $9460 per Year

With coal at $0.40 per ton, realized in a Pennsylvania coal mine by installing an Ingersoll-Rand Class "OC" Air Compressor

In July, 1911, we installed a 30-inch stroke Class "OC-3" Air Compressor, of the type here illustrated, in a Pennsylvania coal mine, replacing two tandem-compound compressors of another make.

In September, 1911, the Master Mechanic's records showed the following savings resulting:

Coal (48 tons at $0.40) - -	$19.20 per day
Water (metered) - - -	1.44 per day
Labor - - - - - -	5.28 per day
Total saving per day (24 hours)	**$25.92**
Total saving per year (365 days)	**$9,460.80**

As the condenser is not yet installed, this saving will be increased when the compressor runs condensing.

Possibly there are savings just as remarkable to be realized in your plant. Our engineers will be glad to help you investigate the question.

ROCK DRILLS AIR TOOLS COAL CUTTERS

INGERSOLL-RAND CO.

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Modern Steel

THE older idea of steel was that it consisted of a combination of iron and carbon in certain proportions, the percentage of carbon present giving correspondingly well determined properties. A steel which was high in carbon was capable of being made hard and of receiving a fine cutting edge, but it was deficient in toughness. A steel containing less carbon was tougher, but also possessed a lower resistance; while a still lower steel was adapted for boiler plate and similar service, but was not capable of being hardened.

The only idea which was associated with the presence of other substances was that they were impurities, acting only in an ingenious manner.

Steel makers who were familiar with the methods and products of that period believed that they could furnish a fairly definite article, suitable within reasonable limits for the service demanded; but they also believed that excellence in one direction was necessarily attained at the expense of excellence in some other direction, and that it was impracticable to secure a material which should be at the same time hard, tough and resistent to fatigue. It was not until the possibilities of using other elements besides carbon in steel were realized that these ideas became modified.

The demand for steels of general higher grade came from the development of new industries; but when the special demands of the builders of gas engines, automobiles and aeroplanes had been effectively met it was realized by manufacturers of tools and of general machinery that what were practically new materials had become available.

Thus, the introduction of the element vanadium into the manufacture of steel enabled the production of a material having at the same time a higher elastic limit, an increased tensile strength, and a greater resistance to shock and vibration. Formerly the increase in any one of these properties meant a decrease in the others; but with the modern steel no such "give and take" appears, and the vanadium alloy steel has all these desirable properties raised together.

The advantages of such improvement may be utilized in various ways. For the automobile, and still more for the aeroplane, it becomes possible to reduce weights without reducing strength. In the case of stationary machinery the dimensions and weights of parts under stress may remain unchanged, while acquiring a much higher resistance than before. This is especially important in connection with moving parts subjected to centrifugal stresses, since any increase in weight involves increased stress, and the only way to secure greater resistance lies in the use of a higher grade of material.

In any case, the use of a material which possesses a greater resistance to fatigue brings with it a longer life.

Apart from the question of capacity to meet the immediate demands of actual service, there is another point which is becoming of increasing importance in modern industrial operations. The demand for greater efficiency, both of men and of machines, includes the requirement that the proportion of idle time be reduced to a minimum. Every moment that a machine stands in enforced idleness means a corresponding proportion of waste, and the advancement of efficiency means little more than the reduction of wastes. When to the actual cost of repairs there is added the charge for loss due to the idleness of the machine, and possibly of others dependent upon it, we realize the full import of the efficiency which is attained by the machine which does not break down. In the case of a locomotive engine, for example, the loss due to the enforced idleness of the machine, if unduly prolonged, may far exceed the actual shop cost of making the repairs.

Vanadium Raises the Useful Strength of Steel Castings 30%

Take two ladles of steel for castings, both from the same melt, the same furnace, at the same time.

Pour a casting from one ladle and after annealing it you will get a yield point or elastic limit between 30,000 and 35,000 pounds to the square inch; it will break under tension at about 70,000 pounds.

Add one-fifth of ONE per cent. "Masvan" Vanadium to the other ladle and pour a similar casting and anneal it precisely the same. You will get a yield point around 45,000 pounds, or 30% better; and a tensile strength approaching 80,000 pounds, or over 10% better than the plain steel; the elongation and reduction also being improved by the small addition of Vanadium.

This means that you can cast locomotive frames, high pressure steam valve bodies, hydraulic and steam cylinders and other severe duty machine parts in Vanadium Steel and get Carbon Steel Forging qualities—great toughness, strength, freedom from crystallization and fatigue, and remarkable durability.

Such things are being done every day—results uniform—castings invariably strong, tough and homogeneous. Vanadium steel castings have been made for all kinds of hard services in sizes weighing from a quarter of an ounce up to 20 tons. Put your problems up to a good steel foundry and specify "Masvan" Ferro-vanadium, nothing else.

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Universal Vanadium Co., General Agents
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Personal

Mr. Irving M. Shaw, having resigned the presidency of the Chelsea Exchange Bank to enter into the mercantile line of business, Mr. A. E. Stilger, for many years vice-president and cashier, has been elected president to succeed Mr. Shaw. The latter, however, retains an interest with the Chelsea Exchange Bank as chairman of the board.

The General Electric Company announce the appointment of Mr. C. W. Stone as manager of the lighting department, succeeding Mr. C. D. Harkins, deceased.

R. Sanford Riley, of Providence, R. I., who, as president of the American Ship Windlass Company, developed the Taylor stoker, has sold out his interest there and organized the Sanford Riley Stoker Company, to exploit a new self-cleaning, underfeed stoker.

Mr. Charles E. Hague has been appointed by the Best Manufacturing Company their Philadelphia representative, with headquarters at 1510 Land Title building. Mr. Hague will have charge of Eastern Pennsylvania, Baltimore and Washington territory.

Best Manufacturing Company, of Pittsburg, Pa., have appointed C. L. Stickney & Co. as their representative in the States of Washington and Oregon, with headquarters at 108 White building, Seattle, Wash.

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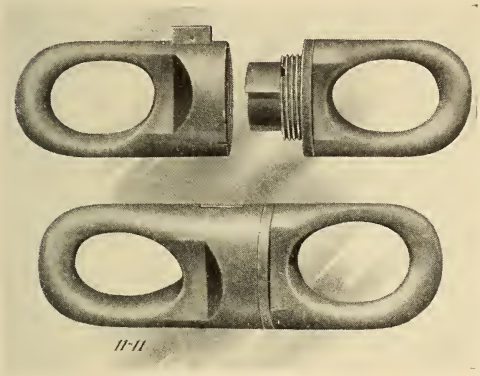
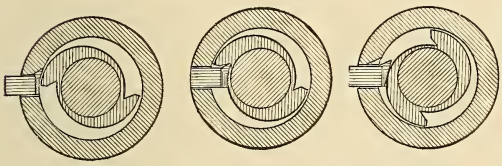
Tension Adjusting Couplings

The "Hunt" tension adjusting coupling is designed for use with the multiple system of rope driving, where each rope in a transmission is connected independently and a sufficient number used to transmit a required horse-power.



COUPLING OPEN AND CLOSED

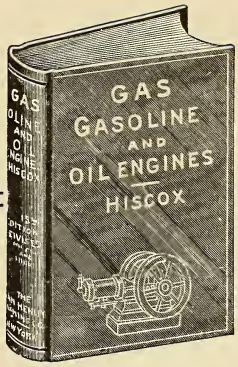


INTERNAL LOCK OF THE ROPE COUPLING

Among the general advantages of these couplings are:

1. The stretch of the rope can be controlled at all times.
2. Ease and rapidity of installation, as a rope fitted with the coupling can be slipped on in a few minutes.
3. Even tension on the ropes is maintained.
4. Work is evenly distributed on every rope in the drive.
5. Freedom from delays on account of resplicing.
6. Cost of resplicing is avoided.
7. The original diameter of the rope is maintained.
8. Particularly adapted to drives with short centres.
9. Specially advantageous for main drives, as they insure constant and uninterrupted operation.
10. Advantageous for plants re-

(Concluded on page 91.)



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A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price.....**$2.50**

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This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price.....**$2.00**

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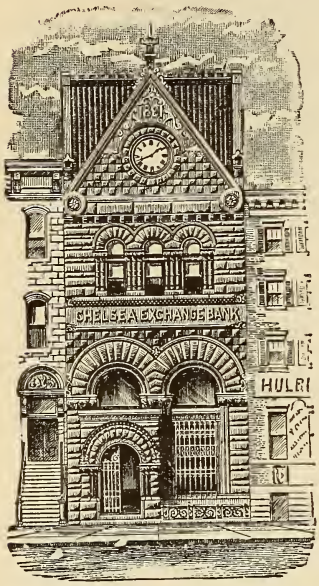

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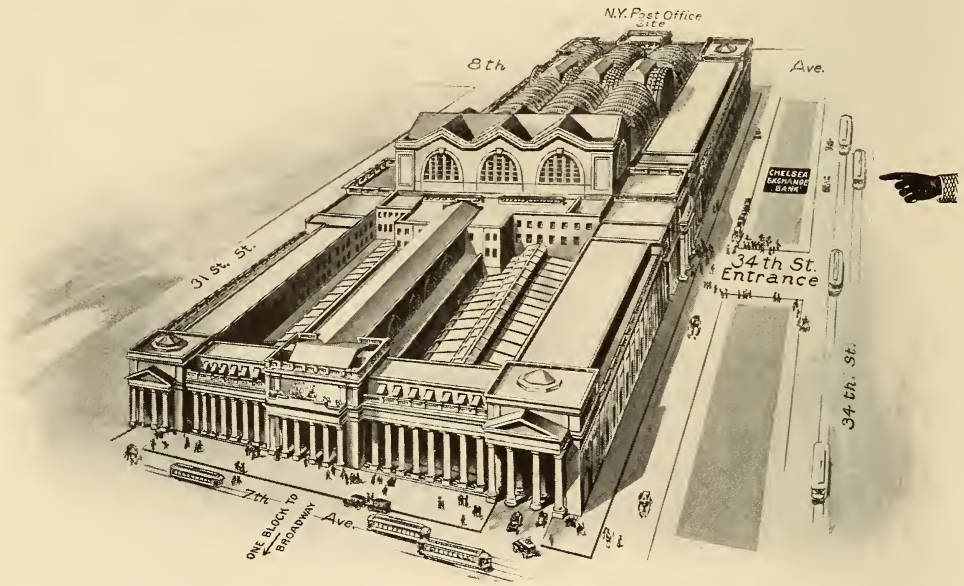

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A FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

OF THE
INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor

CHARLES EASTON, Financial Editor.

The Situation

AS one views from the threshold of the new the political and business side of the old year, he is impressed with the imperative need for constructive legislation and for a crystallized effort on the part of legislators and men of affairs to upbuild public confidence and rehabilitate commercial interests.

Nothing can speak more eloquently for the soundness of general conditions than the fact that business has gone forward in spite of the many hindrances from political and corporate strife.

We recognize the truth of the statement that "it is easier to criticise superbly than it is to do indifferently"; yet it seems to us that some of our Federal officials, Congressional committees and ambitious statesmen, either for the sake of public applause or under the impulse of moral passion, have allowed themselves to be carried beyond the limits of sanity and safety in their attempts to reform large industrial enterprises.

It is regrettable that the methods employed by certain corporations were of such character as to apparently justify the Government in its drastic enforcement of the "Sherman Law." This fact, however, should not be used as an excuse for the wholesale denunciation and disintegration of corporations in general. The men responsible for these methods should be punished to the full extent of the law, because they, and not the corporation, are guilty of wrong-doing. And granting that in human experience perfection is approachable only in degrees, yet we must admit that if men are going to pursue business methods as managerial heads of corporations that they would not stoop to practice as individuals, then our whole corporate system is worthy of nothing less than destruction; but if men will apply to their official acts as officers of these institutions the same principle as they would apply to their personal affairs, then, and in that event, the corporation ceases to be a shield for ignoble acts, and becomes a worthy and useful instrument in the development of the commercial world.

Under the rule of reform, destruction has been swift and decisive and often justifiable. However, we are now confronted with the important task of construction, which requires ability of the highest order, and every man should consider it a moral obligation to aid in its accomplishment during the year of 1912.

A New Weekly Letter
ON
The Trend of the Stock Market

THE TICKER PUBLISHING CO.

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that in response to requests by a large number of readers of "The Ticker and Investment Digest," there is now issued every Thursday a letter indicating the long trend of the stock market, as shown by the study of tape transactions

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I enclose $....., for which you may send me your new Weekly Trend Letter for a period of.....

Name.....
Address.....
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Question—Do you advise the selling of Wabash first extension and mortgage 4s at prevailing prices?

Answer—We advise holding these bonds, as we believe a much better market awaits them. It must be remembered that, physically, the Wabash Railroad is not in bad shape, and we have no doubt but that a satisfactory solution of its affairs will be worked out by the receiver and protective committees.

In regard to the recent authorized issue of fifteen millions 4½ per cent. equipment notes of the New York Central Lines, maturing in annual installments over a period of fifteen years, a public offering will shortly be made by J. P. Morgan & Co., the First National Bank, and the National City Bank at the price of 100¼.

The Postal Telegraph & Cable Company has issued instructions to its construction department to proceed with the erection of additional copper wires between all important points on the system, for the purpose of extending the telephonic use of its wires to independent telephone companies. The recent action of the Postal Company on the Pacific Coast indicates an open war between it and the American Telephone Company.

Question—If a holder of Metropolitan Street Railway stock has not complied with the requirements of the reorganization committee will he be wiped out?

Answer—Failure to deposit old stock of the Metropolitan Company with the committee before December 23, together with payments of $12.90 assessments, will mean that the old stock will be wiped out at foreclosure sale. There is no way that this stock can be held without payment of assessments and still share in reorganization plans.

REAL 6 ESTATE

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though their requirements may be at irregular intervals, or their demand may need part time of an individual only.

If Yours Is Such A Concern

would you not appreciate being able to promptly, by wire, 'phone or letter, have an experienced and reliable man on the spot? To obtain and pay for such services on his part as your actual demand requires

You Can Arrange For Such A Man At Reasonable Expense

A specialty of such representation is made by the undersigned who will give personal and prompt attention to all such business, and will send full information as to experience, terms and references on request.

Why Not Write Him Today You May Need Him Tomorrow

H. C. HORTON
50 Pine St., New York

300 Miles of Steel Pipe Ordered

The United States Steel Corporation has received an order from a firm at Calgary, Alberta, for 300 miles of steel pipe for use in carrying natural gas from Row Island to Calgary, the cost to be about $3,000,000. Shipment will begin January 1, 1912, and will require 2,500 cars, and is expected to be completed within six months.

Question—Do you think the Government's action against the Steel Corporation will interfere with the value of its common stock?

Answer—We would not advise anyone sacrificing steel common because of the Government's suit. It cannot be regarded as attractive at this time, but as a speculation steel common has its possibilities.

Mr. B. F. Yoakum, chairman of the board of the St. Louis & San Francisco Railroad, was very enthusiastic as to business prospects on his return from a four weeks' visit to the agricultural belt of Texas and the Southwest. He stated that on their Brownsville line one day last month there were one hundred and fifty-three emigrant outfits, thus indicating the unusual prosperity of this locality. We are reminded that the Frisco system is particularly fortunate in passing through the Rio Grande valley, which is rapidly developing into one of the most prosperous agricultural sections of the country. This particular portion of the Gulf coast of Southern Texas possesses a climate unequaled on the North American Continent, as it is always springtime and always harvest time, where people live out of doors in comfort from January to December. It is rich in native resources, and is being developed from unprofitable plains and jungles of cactus and mesquite into the richest garden spot in the United States. This remarkable transformation is due entirely to irrigation. The tremendous profits annually earned from farms in this section would be open to question were it not that they are confirmed by such dependable authorities as the Frisco road itself. There is, perhaps, few opportunities for investments that offer the same possibilities of profit with such absolute safety.

During 1911 the American Telephone Company will show an increase close to fifty million in property additions. An attractive feature of this expansion is that it has meant an increase in capitalization of but twenty-six million; the balance of about twenty-four million represents an expenditure upon new property of the depreciation fund.

It would appear that copper producers and copper sellers are absolute dictators of copper prices. The gradual decrease in the surplus has had its effect, and many large users who have not secured their raw material to cover contracts are on the anxious seat.

The Acme White Lead & Color Works of Detroit, the largest competitor of National Lead, has decided to increase its capital stock from $2,750,000 to $4,000,000. The increase is for the purpose of additional working capital.

The directors of the Chelsea Exchange Bank of New York City, at a meeting held last month, elected Mr. A. E. Stilger president, to succeed Mr. Irving Shaw who becomes chairman of the board. Mr. Stilger has long been identified with the Chelsea Exchange Bank as its vice-president and cashier, and is regarded as one of the most able bankers in the city. Mr. Stilger's successful experience in commercial banking has caused him to be looked upon as an authority on credits and "up-town" banking.

THE FINANCIAL BULLETIN

The Only Daily Financial Newspaper in Pennsylvania

THE FINANCIAL BULLETIN is a paper of general financial interest, covering all topics of moment to investors, giving the latest, most accurate and complete news of all financial matters. The staff has recently been increased and the services of several well-known financial writers in Philadelphia, New York, and other important financial centers have been engaged.

THE FINANCIAL BULLETIN has recently adopted the policy of specializing in the news, quotations, earnings and statistics of public utility concerns. There is a large and increasing amount of public interest in utility securities, and a number of the best and most substantial banking houses are interested in the organization and financing of such properties. Investors all over the country are gradually realizing more clearly the stable earning capabilities and development possibilities in this field of investment. It is believed that a daily paper specializing in this field fills a decided need.

Another policy inaugurated which should appeal especially to conservative investors, is that THE FINANCIAL BULLETIN will investigate as carefully as possible the merits of investment offerings before permitting such advertising to appear in its columns. It is our purpose to set a very high standard in this respect, and we assure our readers that only legitimate propositions of intrinsic worth may be advertised in THE FINANCIAL BULLETIN.

THE FINANCIAL BULLETIN is the only daily publication to print complete tables of quotations of the many inactive bonds and stocks held by investors in this territory. It is our purpose to add to these tables from time to time, so that they may continue to be most complete and accurate.

Co-operation is asked from all interested in making successful a publication such as above outlined.

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The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.

Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER

ALBANY, N. Y. Industrial Agent

The Colorado School of Mines Magazine

GOLDEN, COLORADO

Published by the Alumni Association

Monthly, $1.25 the year.

IT IS DIFFERENT. Technical and also interesting. Subscribe **now** and keep in touch with the various activities of the **BEST MINING SCHOOL** in the world and of its graduates. **IT WILL PAY YOU.**

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Write to us when **YOU NEED GOOD HELP.**

THE COLORADO SCHOOL OF MINES ALUMNI ASSOCIATION

GOLDEN, COLORADO

Question—Would you advise buying stocks on a margin for speculative account at this time?

Answer—We certainly would not. It is not safe to buy stocks on a margin at any time and particularly now.

Reports from Pittsburg indicate that the iron and steel business is more active now than at any time during the past eighteen months. The activity is largely due to equipment buying by railroads. In this respect the Pennsylvania road has been among the leaders.

The American Can Company is issuing the following prices for its products that will rule for the season of 1912: For No. 1, $9.00, compared with previous price of $9.25; No. 2, $12, compared with last year's price of $12.50; for No. 3, $16.25, compared with $16.75, and No. 10, $42, same as last year.

A number of anthracite coal companies have advanced the price of rice coal, or No. 2 buckwheat, ten cents per ton, to take effect January 1, 1912.

The Pacific Power & Light Company proposes to increase its capital stock from seven and a half million to twelve million, and is authorizing an issue of two and a half million second preferred stock.

The most encouraging feature in connection with the New York real estate market, according to the manager of the Debenture Corporation of New York, is the gradually increasing demand for real estate investments from out of town sources. According to the same authority, there is very little speculative buying in suburban real estate. The essential feature of all suburban developments to-day is building for homeseekers on convenient terms. The Debenture Corporation of New York has been active in this direction, and are offering six per cent. bonds in denominations of $100, $500 and $1,000 for the purpose of extending its business along this line.

Shop Erection and Testing an Essential of Good Manufacture

THE desirability of erecting and testing all machinery in the shop before sending out for erection in the place of service has long been accepted for nearly every kind of product, and in most instances it is considered a necessity. The principal exception appears to have been that of transmission machinery.

There is no reason why transmission machinery, more than any other, should not be submitted to final test and adjustment before shipment, and there are many reasons why it should be so handled. The principal reason why such erection and testing are not always done is found in the carelessness which is closely related to the general treatment of much of what is termed "ordinary" grades of transmission equipment. Apparently one would think that this is the very kind of product which would require assurance of correct fitting, but it does not work out that way. Carelessness in manufacture means also carelessness of results, and this means that the burden of correcting defects is put upon the purchaser.

A notable exception in this respect is seen in the products of the Dodge Manufacturing Company, the high grade of the entire line of transmission machinery, as manufactured, being completed by erection of each entire job, together with careful test under operation, insuring accurate adjustment of clutches and bearings, verification of truthful balance of pulleys and sheaves, and general precision of all details. This invariable practice of the Dodge Manufacturing Company, one of the elements of the "Dodge Idea," is in no small measure responsible both for the speed with which Dodge transmission systems are erected and for the absence of delays and trouble after operation has begun; and many an order for Dodge machinery has been placed upon this basis as a consideration of essential importance.

DON'T RENT
DON'T BE CRAMPED
FOR SPACE

Move Your Factory to The Country

Build Your Own Shop or Factory To Suit Your Needs And Own It.

WE are in a position to supply factory sites convenient to transportation, either in New York City, or within reasonable distance of it.

FOR PARTICULARS, ADDRESS

The Debenture Corporation of New York

334 Fifth Avenue, New York
SUITE 308

THE NEW HAMBURG-AMERICAN LINER IMPERATOR

EVOLUTION OF THE OCEAN LINER

By M. B. Cea

THE first transatlantic crossing by a steam-propelled ship, although well advertised, was considered so perilous an enterprise that not a single passenger made the trip. This epoch-making event occurred in 1819, when the *Savannah*, an American-built ship, crossed in twenty-nine days. Her cabins accommodated thirty-two passengers. The *Savannah* was but 99 feet in length, 26 feet broad, and with a registered tonnage of 350. She was propelled both by sail and steam, the wheels being crude, side-wheel affairs, which were unshipped and taken on board in bad weather. On reaching Liverpool, the extraordinary sight of smoke issuing from her brought out the harbour fireboat to her assistance.

The public long continued skeptical of the superiority of steam over sails as motive power, and several of the scientists of the period proved to their own satisfaction that the new invention was impractical. The record for crossing was held by the clipper ships. The evolution of the steamship, however, progressed by leaps and bounds. The screw propeller was invented in 1836. The iron ship soon followed, and an iron screw-propelled ship crossed the Atlantic in 1847.

In the early days the dates for sailing were definitely announced in advance, but the date of arrival was too uncertain a matter to be even so

NATIONAL DEFENSE
"MILLIONS for DEFENSE, But not a CENT for TRIBUTE"
"In TIME of PEACE PREPARE AGAINST WAR."
A JOURNAL FOR PATRIOTIC AMERICAN CITIZENS
COLUMBUS, OHIO

DO YOU believe this country ought to be prepared for war? Do you know it is not? Do you want to help make

much as guessed at. It is safe to state that the third cabin accommodations of the palatial liners of to-day are superior to the first cabins of these early steamers. The cabins were unheated, except for the funnels which passed through the body of the ship, while hot water and similar comforts were unknown. In contrast to the sumptuous dinners served on the great modern liners, it is interesting to note that the early tourists were served with salt meats, beans, and the like, and looked forward to the special luxury of plum duff twice each week. The cabins were illuminated by candles.

Within ten years afterwards the modern ocean liner had begun to take definite shape. The elimination of the side wheels had saved considerable room, and this was utilized in enlarging the cabin accommodations. In 1856 the *Borussia,* of the Hamburg-American Line, cut down the crossing to sixteen days. The furnishing of this ship made a great sensation at the time, pointing the way to the luxuries of the great liners of to-day. Her cabins were upholstered with red velvet and hung with mirrors and paintings. The *Borussia* measured 329 feet in length, was of 2,026 tons register, and developed a speed of 12 knots.

The transatlantic steamers were rapidly developed in size, speed and the luxury of their equipment. By the close of the Civil War a crossing was made in 6 days and 19 hours. No less remarkable than the improvement in speed qualities has been the growth in luxury and comfort. It is common to speak of the great modern liners as "floating hotels," but as a matter of fact no stationary hotels in the world are at once so complete and self-contained. In place of the cramped, bare cabins of the past, one may now cross in commodious staterooms and enjoy luxurious libraries, smoking rooms, palm gardens and lounging rooms. Meals are served in palatial dining-rooms, special cafés, grill rooms, or in the private cabins.

Within another year all records for size and luxury of equipment in the transatlantic service will be eclipsed by the appearance of the 900-foot liner. The new giant of the seas, the S. S. *Imperator,* of the Hamburg-American Line, will have a tonnage of 50,000, a beam of 96 feet and nine decks above the waterline.

Both as regards size and luxury of equipment this vessel will establish new standards. This mammoth liner, now in course of construction at the Vulcan shipyards at Hamburg, will be launched next year, and will enter the North Atlantic service in the spring of 1913. The *Imperator* will have a length over all of approximately 900 feet, a beam of 96 feet, and a tonnage of at least 50,000. Some idea of the enormous bulk of the *Imperator* will be gained by the fact that she will have nine decks above the water. Her engines will be of the Parsons turbine type, developing 70,000 horse-power. She will have accommodations for 4,250 passengers and a crew of 1,000. In addition to her regular public cabins, which will be unusually spacious and elaborate, she will carry many special features, including a Roman bath, gymnasium, running tracks, squash court and Turkish and electric baths. The *Imperator* will be equipped with Frahm anti-rolling tanks, which will prevent the vessel from rolling more than two or three degrees from the perpendicular.

it so? Then send fifty cents for a year's subscription and our plan for a league.

NATIONAL DEFENSE

NATIONAL DEFENSE

"MILLIONS for DEFENSE, But not a CENT for TRIBUTE." "In TIME of PEACE PREPARE AGAINST WAR."

A JOURNAL FOR PATRIOTIC AMERICAN CITIZENS

COLUMBUS, OHIO

EMPLOYERS' LIST

Advertisements of positions seeking men, or men seeking positions, are inserted under this heading at the following rates.

No advertisement over 4 ins. accepted.

Style limited to point and faces of type shown in the advertisements below.

Undisplayed Advertisements

One inch, single insertion - - - - - - - - $1.00
Each additional inch in same issue, up to 4 ins. .85

Display Advertisements

One inch, single insertion - - - - - - - - $1.35
Each additional inch in same issue, up to 4 ins. 1.20

Special rates for definite amount of space contracted for to be used as desired during one year, and not more than four inches in any one issue.

WANTED—MECHANICAL ENGINEER, for Packing Company in New England. Must have a thorough knowledge of mechanical motions with view to designing new machines. Experience with modern conveying machinery desirable. Must be willing to assist in accounting department during rush season. Man who has experience with sterilization problems or rudimentary knowledge of bacteriology will be given preference.

Employers' Guarantee Co., Agency, Douglas & Hall, Proprietors, 30 Church St., New York City.

WE WANT MORE MEN. — The demand for skilled draughtsmen and engineers is greater than our supply. Some samples of positions open for high grade men: Heating and ventilating engineer, $30.00 per week. Auto engine and body designer, $35.00 per week. Many others just as good.

Employers' Guarantee Co., Agency, 30 Church Street, New York City.

Translator of French, Italian and Spanish, expert and experienced, desires temporary or permanent work in New York. Address "Translations," care Cassier's Magazine.

EMPLOYERS' LIST
(Continued)

WHAT ONE MAN STATES—"I have advertised in Cassier's Magazine for the last two months, concerning a position, and would ask you to leave out my advertisement in January, as I HAVE OBTAINED THROUGH YOU JUST THE POSITION I WANTED."

A Large Corporation near New York desires a Technical Graduate with experience in elevator, conveyor and structural steel design. Salary about $35 per week. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., Agency, 30 Church Street, New York, N. Y.

A young man with four years' business experience wishes a position as salesman or New York City representative for some reliable concern, who will appreciate a good, hard worker, and will offer advancement. Address 101, care Cassier's Magazine.

SUPERINTENDENT OF CONSTRUCTION WANTS POSITION.—Wide South American experience. Expert on structural steel, reinforced concrete, road building, railroad grading and excavation work. Employers' Guarantee Co., Agency, 30 Church Street, New York City.

Employers' List continued on next page

EMPLOYERS' LIST
(Continued)

ENGINEERS, SALES MANAGERS, COST ACCOUNTANTS—Experts in many lines supplied. We guarantee nothing more than intelligent effort on our part, nor do we charge the employer, but we realize that we must satisfy our clients if we are to continue doing business with them. Office Service Company, 50 Pine Street, New York. An agency for high-class people.

The American Manufacturer who desires to introduce his goods in Italy, can obtain high grade representation by an engineer with American business experience, residing in Italy and engaged in the introduction of articles of American manufacture in that country. There is, at present great demand for many articles of American invention and manufacture in Italy. "Italy," care Cassier's Magazine.

WANTED BY RAILROAD in Western Canada, Civil Engineer to take charge of construction of 150 miles of railroad. Must be thoroughly experienced and have best of references. Employers' Guarantee Co., Agency, Douglas & Hall, Props., 30 Church Street, New York City.

SALES MANAGER wishes to locate with firm of repute, where there is an opportunity of using technical education and experience. Employers' Guarantee Co., Agency, 30 Church Street, New York City.

ADVERTISING MANAGER who can produce results wishes position. Has had wide experience in marketing stocks and bonds. Employers' Guarantee Co., Agency, 30 Church St., New York City.

WANTED—By Mechanical Engineer, in New York, draughting for spare time. Specialty: design of tools for interchangeable machinery. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 30 Church Street, New York, N. Y.

EMPLOYERS' LIST
(Continued)

WHAT ONE MAN WRITES:

"Have advertised here for two months. Having obtained a good position through you, will not need to advertise in January."

HAVE OBTAINED A GOOD POSITION THROUGH YOU.

Display being debarred here, the use of the space must take its place. Correct copy can cut cost considerably in advertising. If the story is right, the title need not be a sign. Plain-Ad Man, care of Cassier's Magazine.

Successful salesman (28), with both office and outside experience desires position in sales department with opportunity to increase the efficiency of the department. Office Service Company, 50 Pine Street, New York. An agency for high-class people.

The Present Business Condition

Statement and Resolution Adopted by the National Founders' Association at Their Fifteenth Annual Convention.

At their recent meeting the National Founders' Association, after most careful consideration by an exceptionally able committee before presentation to their convention, adopted the following statement and resolution:

"To the thoughtful citizen it is apparent that the tendency of much of the State and National legislation is to depress rather than to encourage activities which make for the country's material advancement and prosperity. Political and social unrest

(Continued on page 87.)

NEW BOOKS

The most authoritative and graphic presentation to date of the conflict of Oriental and Western cultures in China.

The Changing Chinese

By

EDWARD ALSWORTH ROSS, Ph.D., LL.D.

Professor of Sociology in the University of Wisconsin, and author of "Sin and Society," "Social Control," etc.

"So interesting is the treatment throughout, so vivid the descriptions, so incisive the arguments, so clear the conclusions, that the volume will appeal to an unusually wide public, and must be considered a notable contribution to the literature on that remarkable land, now undergoing a transformation which is being watched with interest throughout the world."

"Unquestionably one of the books of the hour, Professor Ross's volume on China is destined to remain for many years a standard work of reference.

"A picture of the China of to-day that is surpassingly convincing and interesting."
—Chicago Tribune.

Over 100 illustrations from photographs and Chinese cartoons. An 8vo of 350 pages. Price $2.40 net, postage 18 cents.

Stories of Useful Inventions

By Professor S. E. Forman

Stories of inventions which have registered the development of the human race, skilfully and interestingly told—the first gathering together of these chapters of human progress.

Interestingly illustrated. 12mo, 248 pages. Price $1.00 net, postage 11 cents.

The Second Boys' Book of Model Aeroplanes

By Francis Arnold Collins

Author of "The Boys' Book of Model Aeroplanes"

This is interesting reading for grown-ups as well as for boys. Its treatment of the science of aviation experimentation is practical, explicit, and vivid.

Helpfully and lavishly illustrated. 12mo, 300 pages. Price $1.20 net, postage 11 cents.

THE CENTURY COMPANY
Union Square NEW YORK

BOOK NOTES

Oil Engines

Oil Engines, by A. H. Goldingham. 280 pages. 109 illustrations. 48 page plates, enlarged and partly rewritten and revised. Spon & Chamberlain, New York. Price $2.50.

A thoroughly practical hand-book and a comprehensive treatise on the whole subject of oil engines.

Practical Cement Work

Practical Cement Work, by W. B. Henry. 110 pages. Published by the Concrete Age Publishing Company, Atlanta, Ga. Price, delivered, 50 cents.

This book is an elementary treatise on cement construction and one of the most practical books of its kind ever published, and will prove of great interest to anyone identified with the cement or building industry. It contains, as an introductory, eight pages devoted to historical facts concerning cement and chapters on Natural Cement, Sand, Concrete, Reinforced Concrete, Form Building, Waterproofing, Coloring, Cost-Data, Foundation Walls, Cement Houses, Cement-Plaster and Stucco Houses, Sidewalks, and contains a great deal of valuable information and data based on practical experience.

Change in Numbering Issues of Cassier's Magazine

In order to make the volume periods of CASSIER'S MAGAZINE to correspond with the calendar year, a change has been made in the numbering of the issues, and the volume which was closed with the issue for December, 1911, contained eight numbers instead of six, including the issues from May to December, 1911. The usual volume index and title page, for use in binding the magazine, will not be contained in the magazine, as heretofore, but will be mailed without charge to anyone who will write requesting it. The present number, January, 1912, will therefore be the first issue for Volume Forty-one.

writing to Prof. E. W. Kerr, M. E., Department of Mechanical Engineering, Louisiana State University, Baton Rouge, La., and mentioning CASSIER'S MAGAZINE.

The Present Business Condition

(Continued from page 85.)

find expression in extreme measures which seriously disturb economic stability. Radical and unwarranted legislation is proposed as the panacea for every ill and every shortcoming. Political mountebanks feed upon prejudice and build upon hatred and selfishness. The pendulum of public opinion, therefore, has swung to extremes, and has caused apprehension and uncertainty where confidence and certainty should prevail.

"In the meantime, a country whose normal temperament is hopeful and optimistic, a land of wonderful resourcefulness and boundless possibilities, of remarkable energy and constructive ability, is languishing under a prolonged industrial depression.

"That the panic of 1907 was primarily a financial disturbance which should be followed by a period of industrial depression was to be expected. That this depression should be prolonged over a period of years is unwarranted, and must be laid to causes which should and must be removed. Be it, therefore,

"*Resolved,* That, in the judgment of the National Founders' Association, the time has arrived when the country should awaken to the real situation, discountenance public expressions and legislative action designed to discourage legitimate enterprise and commercial and industrial development, and denounce the political tinkerers who destroy confidence and undermine the economic stability of a great nation. And be it further

"*Resolved,* That we bespeak for the American people a returning confidence in themselves, a conservative attitude on all controversial problems and the application of sane methods to their solution; a more friendly cooperation between capital and labour,

A New Method for Distributing Manufacturers Catalogues

The Manufacturers' Library, a free reading room and a library of Manufacturers' catalogues, including models, tools and other exhibits, has just completed its first year of activity.

The Library is an adjunct of the Commercial Bureau Company, and is located at 50 Church Street, New York City. It serves the double purpose of a reference library to buyers from out of town and a club house for business appointments, etc., where buyers and manufacturers or their representatives may meet and transact their business, receive their mail or telephone messages; in short, a place where they may attend to all their business while in the city. No charge is made for the facilities offered except a nominal fee for the use of the stenographers, and telephones.

In addition to Manufacturers' catalogues the Library also contains a great assortment of domestic and foreign trade literature (about 800 Trade Journals are regularly received) and is also free for reference to buyers and manufacturers. The catalogues and trade literature are briefed and indexed on separate cards and offer ready access to classified information. Manufacturers may file duplicate catalogues for distribution.

A number of similar library bureaus will be opened in the course of this year in the principal cities abroad, and will be in intimate relation with the Manufacturers' Library in New York.

In Europe the question of bringing buyer and seller together has been given more attention than in this country. England and Germany have even appointed commissions that have studied the problem from a scientific point of view, and their recommendations after about two years of research have led to the establishment of libraries similar to the Manufacturers' Library conducted by the Commercial Bureau Company.

The Manufacturers subscribing to the Manufacturers' Library are entitled to file their catalogues, prints or printed literature, photographs, etc., for an annual fee of $5.00 for each Library used, it being optional with the subscriber to take any part or all of them.

ROMEIKE'S

Press Clippings

are used nowadays by every up-to-date business man; they bring you in constant touch with all public and private wants and supply you with news bearing upon any line of business.

We read for our subscribers all the important papers published in the United States and abroad.

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drop us a postal and we will show you how they can be

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The largest firms here and abroad are on our books.

LET US send you clippings from newspapers and periodicals of the entire globe. We cover every topic, every subject, and every country.

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Otto Spengler, Director

352 Third Avenue, New York

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LONDON PARIS BERLIN VIENNA MILANO

between employer and employee; that we impress upon the agencies of government the duty to promote rather than retard the progress and prosperity of a whole people."

Getting the Industrial Elements Together

In the February, April, May, and June numbers of this magazine there appeared a series of chapters of an article entitled "Diagnosing an Industrial Disease," by H. F. J. Porter. These articles attracted a great deal of attention and set many people thinking along certain lines which were new to them regarding ways of solving some of the industrial problems of the day.

Mr. Porter pointed out very clearly that no one factory can reach its highest efficiency by itself, because there are many factors entering into its problems which it cannot control. Take, for instance, the seasonal fluctuations of the trade which it cannot by itself effect. Take, again, the volume of supply of the raw material which it needs and the supply of the skilled labour it requires.

All of these and other items are controllable only by getting all the factories in the special industry to come together and arrange to regulate these matters on co-operative lines. This means scientific management, not only of each individual shop, but of the industry as a whole.

It is to consider these problems on the lines indicated that the "American Society for Promoting Efficiency," of which mention has been previously made in these columns, will devote its attention. It is interesting that there are included in the membership of this society men connected with the government of the country, which is being called upon now to regulate the "trusts," which are simply large industrial groups.

It will be possible for the various elements entering each industry to get together "in committee," and these committees, by comparing notes,

can lay down general plans which all may follow, and beyond these each must meet its own requirements. If "labour," which seems just now to be the victim of bad leadership, will break the traces and enter this society in time to join in these conferences, many of the problems referred to will be materially simplified, and "labour" will benefit tremendously on its own account.

The Typewriter Operator and Her Nerves

(Concluded from page 62.)

or printing moment there is a yield to the finger key which softens the blow and relieves the finger of the operator of undue shock. In this way greater advantage is taken of the force of the stroke of the finger upon the key lever, less power is wasted in overcoming the inertia of the typebar, and a hard blow is delivered upon the platen with a minimum of effort. Indeed, the impact of the typebar is so great that operators soon learn that not more than one-third the expenditure of physical force is required to do good work, as compared with the machines they have formerly used. In the course of a day this makes for a large saving of nerve energy and minimizes the danger of producing nerve disorders.

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PLACE MEDINA
NAPLES, ITALY

Located in the center of the city
in a high and healthy position.
All Modern Comforts.
Moderate Prices.
Ideal for American Tourists.

ITEM & CAPPUCCIO - Directors

THE LATEST CATALOGUES

Recording Instruments

The Bristol Company, of Waterbury, Conn., have issued a condensed catalogue of their recording gauges, pressure gauges and other recording instruments, which has been designed to furnish sufficient data in convenient form to enable customers to conveniently specify their orders, but not to take the place of the more complete catalogues of their instruments which they issue. The book gives, in addition to the lists, detailed specifications and prices of the models illustrated, same being given at the foot of each page on which illustrations are printed, and engineers will find its arrangement exceedingly convenient for specifying their requirements.

It also contains a list of separate catalogues issued by the Bristol Company, each catalogue covering one of their well-known instruments for recording pressure, temperature, electricity, time, speed, etc., of which latter bulletins they will gladly send copies on request.

Every engineer should possess a copy of this new catalogue, as it will be found most convenient and valuable, forming, as it does, not only a condensed description of their instruments, but a complete catalogue of all their publications, so arranged that information concerning any class of recording instrument can be ascertained with ease.

In requesting a copy, mention Condensed Catalogue No. 160 and CASSIER'S MAGAZINE.

Air Compressors

New Catalogue No. 19 just issued by the American Air Compressor Works, 26 Cortlandt street, New York, contains an exceedingly interesting introductory.

Under the title of "Facts About Jenkins Brothers' Valves" there has just been issued by Jenkins Brothers, of New York, a convenient book, giving clearly and concisely much information covering the well-known Jenkins valves. This little book will, without doubt, prove of service to steam users, and copies can be obtained by addressing them and mentioning that you saw a notice of it in CASSIER'S. While the Jenkins valves are known wherever steam is used, this, their latest booklet, contains the last word regarding them.

Locomotives for Industrial and Contractors' Service

An exceedingly interesting record of locomotives which the Baldwin Locomotive Company have designed and built to meet unusual operating conditions in industrial and contractors' service has just been issued by them. The book describes fourteen of such locomotives, which were constructed to meet special requirements covering a wide range in capacity, from light, narrow-gauge locomotives to heavy units suitable for handling standard gauge equipment in railway yards or industrial establishments. As usual with the publications issued by this company, it is a handsome work and very finely illustrated, while the subject is clearly presented, fully covered, and yet so arranged as to make it instantly available to the busy man. By mentioning Record No. 71, CASSIER'S, and writing the Baldwin Locomotive Works, Philadelphia, Pa., a copy may be obtained, and it will prove valuable to those having to do with transportation problems.

Expulsion Fuses and Fuse Holders

The General Electric Company has just issued Bulletin No. 4899, illustrating and describing its expulsion fuses and fuse holders. These are for use on circuits having voltages up to and including 110,000.

Rock Drills

Bulletin, Form 4108, issued by Ingersoll-Rand Co., 11 Broadway, New York City. Catalog of four pages, descriptive of the B-104 Sergeant rock drill, which is a machine specially adapted for driving small headings, stoping or similar work, requiring a light and small, but powerful machine. This drill has a 2½-inch diameter cylinder and will drill a 1-inch to 1½-inch diameter hole to a depth of 20 inches without change of steel. Bulletin shows duplicate parts of the drill and also gives full specifications and details.

On Thursday, November 16 last, Mr. Richmond Viall, superintendent of the Brown & Sharpe Manufacturing Company, of Providence, R. I., died in Newport, R. I.

Mr. Viall was born in Barrington, R. I., in 1834, and entered the employ of the Brown & Sharpe Company as a workman in 1863. Later, becoming a foreman, he was connected with the manufacture of sewing machines. In 1878 he became superintendent, a position which he retained until his death.

Mr. Viall was an able director of men and devisor of methods, always a teacher, regarding his men as pupils, and a friend to all his workmen, who numbered thousands. He promoted the best in design and honest workmanship, was very loyal in service and wise in counsel, and his labours remain an inspiration to all who came in contact with him.

PRACTICAL CEMENT WORK

A NEW BOOK ON CEMENT CONSTRUCTION

By W. B. HENRY

FREE

To every new subscriber, or renewal for Two Years to Cassier's Magazine received before March 31, 1912.

The Cassier Magazine Co., 12 West 31st St., NEW YORK

New catalogues are received from Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., describing Westinghouse D. C. switchboard meters, watthour meters, Type C; Westinghouse A. C. switchboard meters and watthour meters, Type O A, and Westinghouse electric tailor's iron.

Thomas H. Dallet Company, Philadelphia, Pa., "Dallett" pneumatic boiler scaler, a labour-saving tool for the boiler room.

Keuffel & Esser Company, New York, mathematical and drawing instruments.

Ingersoll-Rand Company, New York, "Little Giant" rock drills and "Imperial Type X" duplex steam-driven compressors.

Tension Adjusting Couplings

(Concluded from page 73)

motely situated, where the services of a competent operator to resplice ropes cannot be obtained.

11. They are of special advantage when the driving side of a transmission is on top, as they control the extra sag on the lower side.

The coupling is made of steel and in two parts, which screw together. It is fitted with a small dog, which holds the parts in position and acts also as a ratchet when tightening the rope to take out the slack. The shortening of the rope is effected by holding one-half of the coupling rigidly and turning the other so that more twists are put in the rope and thus made shorter. The shortening is done without removing the rope from the pulleys. After the rope has been tightened sufficiently the dog is pushed back into proper position entirely flush with the outside of the coupling.

The couplings are spliced into the rope at the works and the bands finished to the correct length, ready for immediate use when received.

The C. W. Hunt Company, 45 Broadway, New York, N. Y., are the manufacturers of this coupling, and full information can be obtained by writing them and mentioning this article.

LAUGHLIN
Safety Self Filler
Fountain Pen

Cut Showing Barrell Drawn Apart Exposing Pressure Bar, Ready for Refilling

Guaranteed absolutely non-leakable—pen and feed kept moist and primed, insuring a free, uniform flow of ink instantly upon contact with writing sheet.

May be carried in any position in pocket or bag without possibility of leaking or sweating.

Every pen guaranteed satisfactory to the user or money refunded. Size illustrated in this advertisement **$2.00** by mail prepaid to any address, plain black chased or mottled as desired.

It is not necessary to write us a letter; simply pin a $2.00 bill to a slip of paper containing your name and address and we will mail the pen by return mail.

Send us the name of your dealer,

that you asked to show you a LAUGHLIN Non-leakable Self-Filling Fountain Pen, and we will send you FREE OF CHARGE one of our new Safety Pocket Fountain Pen Holders.

It is not required that you purchase a pen to get this Safety Holder. We simply want the names of dealers who do not handle this pen that we may mail them our catalogue.

We will appreciate this favor very highly.

Address,

Laughlin Mfg. Co.
797 Griswold Street
Detroit, Mich.

DO YOU KNOW?

a useful enclosure sent with your letter or an attractive article given by your salesman when soliciting business creates a kindly feeling towards you from the start?

DO YOU KNOW?

a pencil, nail file or other advertising specialty costs no extra postage? It is a little salesman requiring no fares or hotel bills and yet influencing business.

DO YOU KNOW?

I can refer you to cases where orders were secured by the use of advertising specialties which could be obtained in no other way? **They have helped others—they will help you.**

I HAVE

desk rulers, steel rules and tapes, paper weights, wallets, court plaster cases—in fact anything you wish from a toothpick to a clock.

Let's get acquainted and push for a bigger business in 1912

WILLIAM PARKER PERKINS

ADVERTISING SPECIALTIES

116 NASSAU STREET, NEW YORK CITY

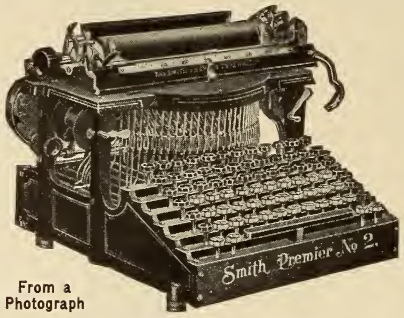
Copy of "How I Lost a Prospective Customer" FREE

THIS SMITH PREMIER $26!

STANDARD TYPEWRITER—YOURS FOR

For more years than you probably can remember, the Smith Premier Typewriter has been recognized as *One of the Two Leaders* among standard $100 typewriters.

The Model No. 2, shown here, writes 76 characters, including the alphabet in capitals and small letters, figures, punctuation marks, etc. It has 76 finger-keys, "A key for every separate character." Hundreds of thousands of this model are in use to-day.



From a Photograph

Your Opportunity

to purchase this famous typewriter for practically one-fourth of the makers' price is due to the new Visible Writing Smith Premiers, for which **No. 2 Models were accepted as part payment.**

By an exclusive purchase **we got all of the turned-in No. 2 machines,** and are thus enabled to offer the best of them (some but little used) at this unheard-of low price.

Your Guaranty

of satisfaction in the typewriter you buy from us is this seal—placed on the machine itself—equivalent to the makers' original guaranty.

The Other Fellow's Impression

When you receive a *pen-written* letter from a business or professional man in these days, don't you immediately lower your opinion of the sender's importance?

Then how can *you* afford to send out scribbled correspondence—bills of account—estimates—reports—orders—(whatever your need for writing may be) to represent *your* business or *yourself?*

Typewriting Easily Learned

Anyone can operate a Standard Typewriter. You can learn all you need to know about the machine in one evening and finish by writing a letter.

Speed comes with use; a novice can soon write as fast as a rapid pen-writer (20 to 30 words a minute), and an ordinary stenographer easily typewrites *twice as fast* as pen-writing.

For practical use, year in and year out, there is no other typewriter that will give you better service than the Smith Premier.

"American Factory Rebuilt"

The Smith Premier typewriter we offer you has just gone through our Newark factory. Our expert workmen have dismantled the entire machine, examined it thoroughly, and replaced every worn or defective part with a new part.

Thoroughly reconstructed, realigned and readjusted, this typewriter **performs like new.** Refinished and renickeled it **looks like new.** We fully guarantee it for one year.

Free Trial

Sign the coupon below and mail at once—no obligation, no expense to you—and we will write you how you can examine and try this typewriter in your own home—to prove to your satisfaction that it is exactly as we say.

Promptness will be wise, for there are only a limited number of these typewriters for sale.

AMERICAN WRITING MACHINE CO.
345 Broadway, New York

Please mail me full particulars of the Free Trial Offer of a Smith Premier Typewriter for $26.00, without any obligation or expense on my part, as advertised in Cass.

NAME.....

ADDRESS.....

HOW RAILROADS AID INDUSTRIAL DEVELOPMENT

To the man seeking land for fruit culture, for which much land in this region is naturally adaptable, for dairying and intensive farming, etc., as well as to those who desire cottage or summer home sites, either in the far-famed Adirondack Mountains, on the shores of Lake George and Lake Champlain, or in any of the beautiful country spots throughout its territory, the industrial department of the Delaware & Hudson Company offers its services free of any charge, believing, as it does, that the way for a railroad to prosper is to aid in all proper ways the prosperity of the region it serves.

GENERAL ELECTRIC COMPANY, SCHENECTADY, WORKS IN 1886

At Schenectady, N. Y., is located the largest of the four plants operated by the General Electric Company, the largest manufacturers of electrical devices in the world, their products covering every type of electrical equipment, from that required by the largest power house for the operation of a railway system to the motorman's controlling handle, and everything of an electrical nature required by the largest lighting central station, even to the tiny incandescent lamp or household appliance, including sockets, wire, cable, cut-outs, panels, meters, transformers, etc.

The General Electric Company operates four plants, located, respectively, at Lynn, Mass.; Pittsfield, Mass.; Harrison, N. J., and Schenectady, N. Y. This latter plant employs about 14,000 people, covers more than 100 acres with its buildings alone, exclusive of yard room, has a general area of 335 acres, while its buildings afford 4,580,000 square feet of floor space. At this plant it possesses 12½ miles of railroad of its own.

Its general office building, at the entrance to this plant, is the largest building in the world occupied by a single company, and in it 1,800 persons are employed in the company's executive, commercial, engineering, law, patent, auditing, production and publication departments.

It is at the Schenectady plant that the General Electric Company maintains its system of standardizing, testing and research laboratories, where the most suitable materials to be used in construction are determined by electrical and mechanical analysis, new methods and means of manufacture

are carefully sought after and developed, and new machinery invented or existing products perfected.

In the four principal plants of the General Electric Company the total land area consists of 608 acres, the total floor space of the buildings is approximately 8,500,000 square feet, and the total number of employees about 35,000. In land area and floor space of buildings more than half are represented by their Schenectady plant, while nearly half of its employees are there, which indicates its vast size and importance.

The local plant of the American Locomotive Company constitutes one of the leading industries of Schenectady, and is another indication of the wonderful development of this territory.

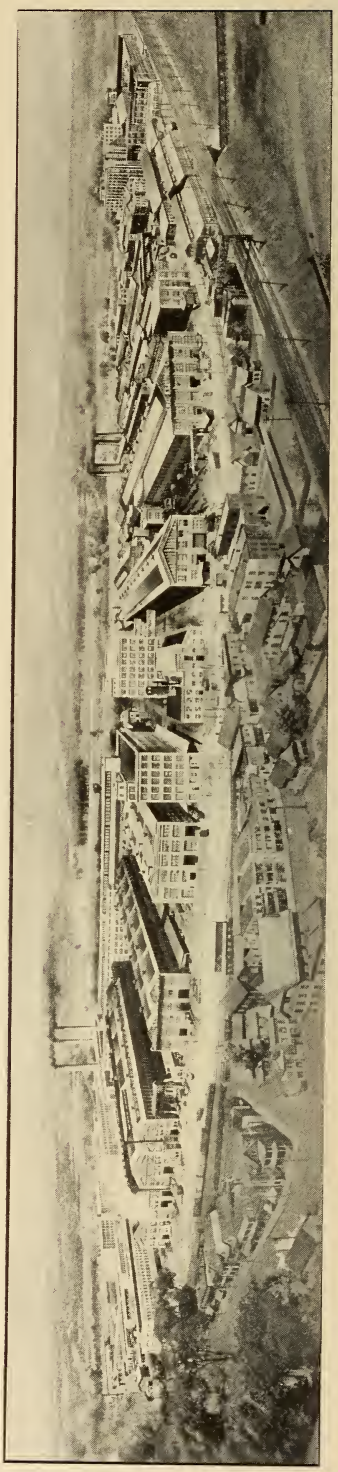
The largest and most important of the nine (9) plants of that great corporation, it is also one of the oldest locomotive manufacturing concerns in the country. It was established under the name of the Schenectady Locomotive Engine Manufactory in 1848, part of the original capital being raised by the citizens of Schenectady, and, except for a few shutdowns, due to temporary depressions in business, the works have been in continuous operation since that time.

The history of this plant, therefore, covers almost the entire period from the time locomotive building was first begun in this country.

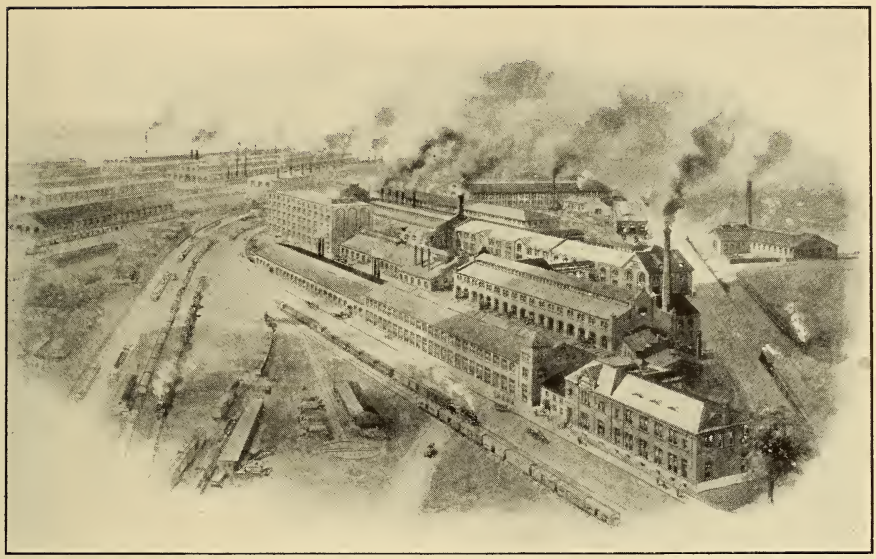
At present the plant covers 65 acres of ground and comprises forty-four buildings. At full capacity, the employees number 6,000, who, with their families, constitute, conservatively estimating, a total of 18,000 people, or practically one-quarter the present population of the city, who derive their support from these works.

One of the latest products of the plant is the locomotive here shown, the fifty thousandth locomotive of the American Locomotive Company.

This is an experimental passenger locomotive designed and built at the expense of the company in or-



GENERAL ELECTRIC COMPANY'S SCHENECTADY WORKS, 1912

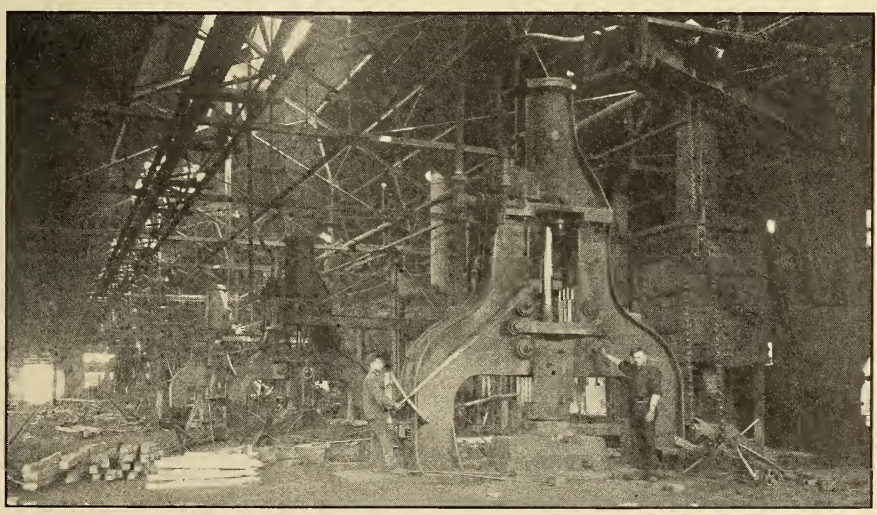


SCHENECTADY WORKS—LARGEST OF THE NINE PLANTS OF THE AMERICAN LOCOMOTIVE COMPANY

der to determine the possibilities of capacity and efficiency of a locomotive of standard wheel arrangement embodying the latest approved developments in locomotive design, construction and material; in other words, to secure the maximum sustained capacity per pound of weight.

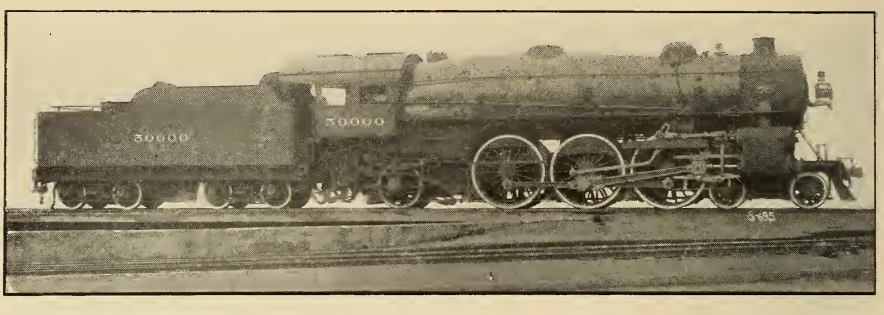
By service tests, it already marks a distinct step in advance in locomotive engineering.

It constitutes, probably, the first instance in the history of American locomotive development in which locomotive builders, at their own expense, have constructed a locomotive,



MAMMOTH 8,000 AND 7,000-POUND CAPACITY STEAM HAMMERS, HAMMER SHOP, SCHENECTADY, WORKS, AMERICAN LOCOMOTIVE COMPANY

Showing Niles-Bement-Pond Company, William Sellers & Co., and Chambersburg Engineering Company Steam Hammers.



EXPERIMENTAL PACIFIC TYPE LOCOMOTIVE, AMERICAN LOCOMOTIVE COMPANY'S 50,000TH LOCOMOTIVE

not to introduce a new principle, but to secure information as to the maximum possibilities inherent in already accepted principles with the view to the advancement of locomotive design.

The American Locomotive Company has the largest output capacity of any corporation of its kind in the world, and can turn out one complete locomotive for every hour of each ten-hour working day a year.

The two largest iron ore mines in the eastern part of the country are both within the territory of the Delaware & Hudson Company—the Mineville-Port Henry district, operated by Witherbee, Sherman & Co., of Port Henry, N. Y., have spent in the last eight years over one and a half million dollars in development, and have three concentrating plants in operation and four in course of construction; the Chateaugay Ore & Iron Company, at Lyon Mountain, N. Y., with an estimate of one hundred million tons to draw from—ore known to the trade as low phosphorus and the best in the world. It is also separated by magnetic process, and the iron is used in the manufacture of high-priced steel products, such as armour plate, projectiles, piano wire, etc.

The managers of railroads to-day are awake to the fact that the prosperity of the territory through which they pass means their prosperity; that the more intensive the development of such territory, the more lasting and constantly increasing will be their business, and are doing all in their power, both by fair and equal treatment to all and the expenditure of a vast amount of both money and energy, in proper methods to further the accomplishment of such development, a development in which the entire country shares.

Pay Gravel

Pay dirt, or pay gravel, is generally associated with early gold mining days; but at present gravel itself, and not the gold contained in it, is a great producer of wealth.

Due to the more extensive use of gravel and sand in concrete construction work in recent years, particularly in New York and other large building centres, the amount of gravel and sand dug and sold each year is rapidly increasing. Last year in the United States more than $21,000,000 worth of them were sold, the total amount being 69,410,436 short tons, which represented an increase over 1909 of nearly 10,000,000 short tons.

At present greater appreciation of the importance of using proper sand and gravel in cement and concrete is being shown, leading architects and builders now requiring and demanding sound, clean-washed material.

The value of the sand and gravel dug and sold, as mentioned above, is not far behind that of our present annual production of silver.

KEEPING TRACK OF COMING EVENTS

By O. D. Lee

THE old saying, "A place for everything and everything in its place," is all right as far as it goes, but a great deal depends upon how well thought-out that place has been; in other words, is it the right place for the certain thing placed in it?

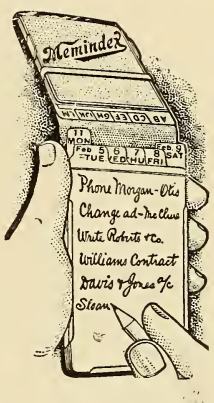
We are told that we of the present day live too rapidly, that improved methods of communication push everyone to extreme rapidity, both of thought and action, and that this is especially true of America.

That the telegraph, telephone, automobile, etc., are time savers no one disputes; yet, while savers of time they have all tended to condense much necessary action in short periods, and to add to the mental strain of present-day life by multiplying the number of things necessary to be done each hour and lessening the time available for their performance.

The man of this century has much more to remember than ever before: events crowd themselves in quick succession on his mind; appointments, calls, demands, orders, instructions and information to be retained crowd upon him with great rapidity, until the brain is weary with trying to remember details; and no memory system can lighten the burden, no human brain can stand the strain and give the highest efficiency in service.

It is to meet just this condition that there has been perfected a simple device called the "Memindex," so simple in its management that it is nearly automatic, so certain in its results that, once used, it is never discarded, and one only wonders how his work was carried on without it.

This device saves time, because you do the right thing at the right time; you plan your work and work your plan. Saves money, because important matters are not neglected; opportunities, appointments and obligations are promptly met. Saves energy, because it is not misdirected, and thus you get a full hour's value out of every hour. Further, it prevents waste and stops small leaks; prevents worry, because you obtain the best results of which your mental and physical equipment are capable, and prevents forgetfulness—that foe of successful accomplishment.



The memindex consists of a pocket-case, cards and filing case so arranged that they form an equipment which will handle the records of a large business systematically and give results without red tape or so-called systems, which often results in more money than was the case before they were used.

There are many kinds of card indexes on the market, but, to the writer's mind, none that approach in any way the practical worth of the memindex.

The memindex consists of a series of cards, 2¾ x 4½ or 3 x 5½, as may be desired, with proper guide cards designed for many and varied

(Continued on page 86.)

ROTARY CONVERTERS FOR MINING SERVICE

Direct current is necessary for the operation of mining locomotives, for the reason that alternating-current motors cannot satisfy the speed and space requirements. Rotary converters are now being used in many coal and metal mines, being the logical machine for efficiently converting the alternating current used for the transmission of the energy from the steam or hydro-electric generating stations to the mines to direct current at the point where the energy is used.

Several public service companies in both Pennsylvania and in Colorado companies find it economical to establish steam or hydraulic generating stations at points where energy can be generated cheaply and to transmit it as high-tension alternating current to the mine, or group of mines, where it is utilized. Whether alternating energy is generated by a public service company or by the mining company, experience shows the rotary converter to be an efficient, reliable machine for converting the alternating to direct current. A nominal voltage of either 275 or 600 is adopted for the direct current distribution systems within the mines.

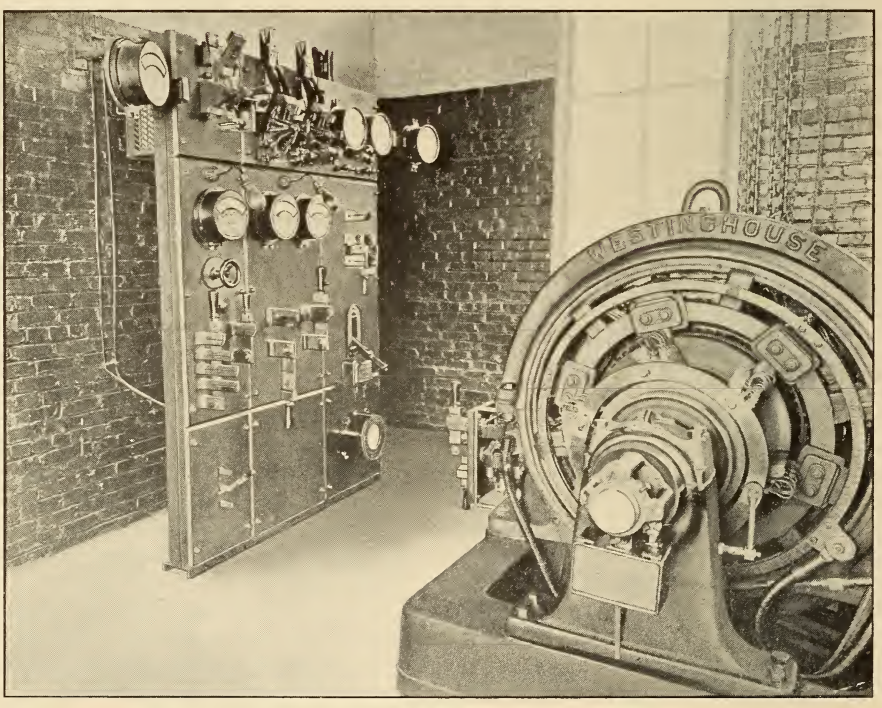


FIG. 1.—ROTARY-CONVEYOR INSTALLATION, MINE 22, CONSOLIDATED COAL COMPANY OF PENNSYLVANIA

are making a specialty of supplying mines with alternating current energy and are developing excellent mining loads. The larger mining

A good example of a mining plant rotary-converter installation is shown in Fig. 1, which is a view of the substation at Mine No. 22 of the Con-

solidated Coal Company of Pennsylvania. This station receives energy as alternating current at 2,300 volts, three-phase, 60 cycles. The pressure is stepped to 158 volts for the alternating side of the Westinghouse 150-kilowatt rotary, and is delivered therefrom as direct current at 275 volts. A standard Westinghouse black marine-finished switchboard, carrying the usual switch gear and instruments, controls the incoming alternating-current line, the rotary converter and the outgoing direct-current feeders, which radiate to different parts of the property.

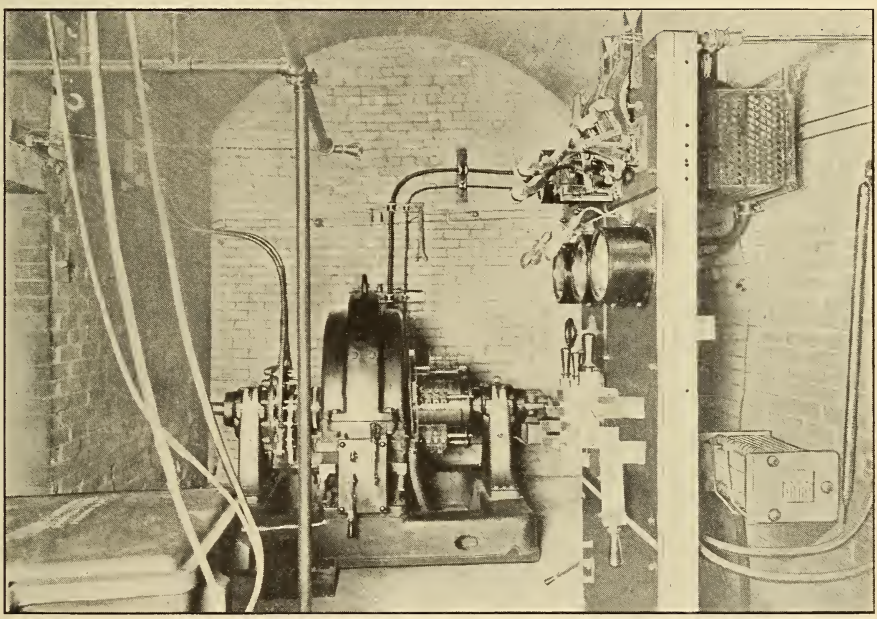


FIG. 2.—UNDERGROUND ROTARY CONVEYOR SUB-STATION, CONSOLIDATED COAL COMPANY

In large mines it is sometimes expedient to locate rotary converter sub-stations underground near the centre of the area they serve. Such an underground sub-station of the Consolidated Coal Company is shown in Fig. 2. The room forming the station is lined with brick, which is waterproofed on the outside, and the roof is arched so that it will drain and that dripping water cannot damage the apparatus. The incoming lines to this station are alternating current, 2,300 volts, three-phase, 60 cycles, and the 150-kilowatt rotary converter delivers direct current at 275 volts. The transformers, stepping down from the alternating transmission voltage of 2,300 to the alternating rotary voltage of 158, are located in the sub-station (see Fig. 2). A pipe framework arranged over the high-tension transformers supports the high-tension bus-bars. A two-panel, black marine-finished switchboard carries the equipment for metering and controlling the incoming and outgoing lines, the transformers and the rotaries.

Armoured, lead-covered cables are generally used to convey the high-voltage energy to an underground sub-station in a mine. The cable is usually carried down a bore-hole rather than through the workings, so that the chances of injury from falling rock and from interference will be minimized.

Efficiency

WE hear a great deal said today about efficiency, and, upon closer examination, it appears that different meanings are given in various quarters to this rather overworked word. In some instances the term efficiency is used in the sense of effectiveness, so that if a man or a machine is, in any way, caused to accomplish more than formerly, it is said that a greater efficiency has been attained. A more correct usage of the term efficiency, however, is that of the percentage of return which is secured from any effort, this percentage being computed upon the total effort put into an undertaking and the useful effect taken out.

Sometimes it is not easy to find out just how much effort has really been put into a job, and especially with things which are done by human or animal muscular effort there has only lately been any reliable information as to the real operations of animal energy. There has also been some confusion, in the case of work performed by men, of the purely physical effort of the muscles and the guiding and directing functions of the brain.

In all such discussions, however, it is now generally accepted that human energy, considered as muscular power, should not be used if the work to be done can be performed by machinery, since the cost of man power, compared with the same effort produced by mechanical power, is far too great to meet modern efficiency requirements.

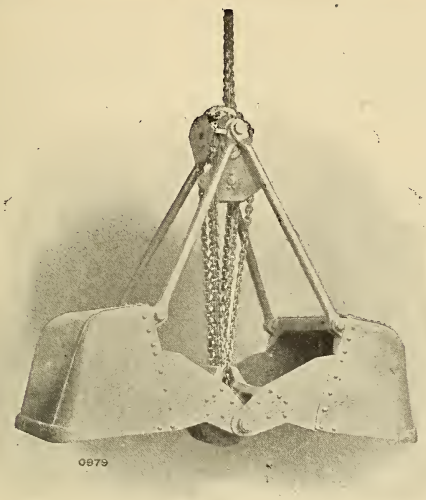
Even the simpler kinds of work, such as shoveling coal, earth or ashes, should be performed by men only when the local conditions, or the temporary nature of the job, render the use of mechanical devices impracticable. The excavation of the canal at Panama, conducted almost wholly by power shovels, dredges, buckets and conveyors, is being effected far more efficiently than was the much simpler task at Suez, largely because the latter work was performed by manual labour.

It would hardly do to use an oil tractor to cultivate a small garden, but it is the employment of just such machines which has enabled farming of the largest scale to be conducted with an efficiency unattainable by the older methods of manual and animal power.

The modern epoch, which depends so much upon the manufacture of power to replace human effort, has caused the erection of great power houses in manufacturing centers, and it is in such establishments that the efficient use of mechanical appliances especially appears. The fuel is brought either by water or by railway, and taken mechanically from the hold of the car and lifted into storage bins at such an elevation that it may utilize the energy thus stored in its mass to affect all its further movements until it is consumed. Even during the operation of combustion the necessary volume of air is often supplied mechanically, while the non-combustible portion is removed mechanically as ashes and delivered to the car or boat, by which it is removed to be used as filling elsewhere.

In cases for which mechanical devices have not been satisfactorily produced, such as the stoking of locomotives, it is appearing that the limitations in power are likely to be found in the capacity of the fireman to handle the necessary amount of coal, and this is one feature which may lead to the use of stationary power houses and electrically transmitted power, even if other considerations do not render such a change desirable.

In any case, the importance and desirability of relieving man from the burden of exhausting labour should be taken into account and every effort given to the performance of the purely mechanical side of an undertaking by machinery, leaving to the man the far higher function of its direction and control.



HUNT GRAB BUCKET

For Handling Coal, Ore, Broken Stone, etc.

Note the width of the opening of the shovel

THESE BUCKETS TAKE A FULL LOAD QUICKLY AND EASILY IN ANY POSITION, NO MATTER IF DROPPED SUDDENLY OR IF LOWERED GENTLY.

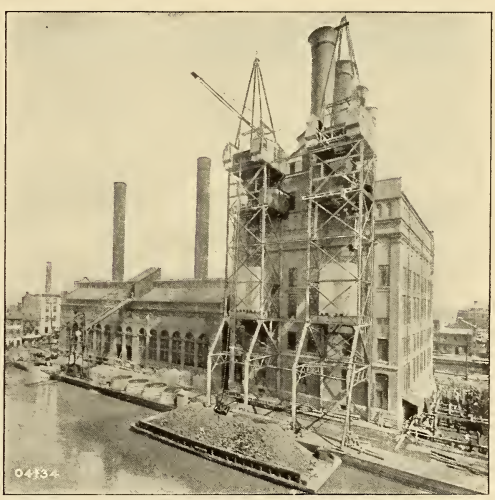
IT is the only bucket on the market that will dig splint coal satisfactorily and is the best bucket for digging lumpy run of mine coals.

They are of unusually heavy and strong construction.

The main bearings are brass-bushed and when worn a new bushing will bring the bucket back to its original effectiveness.

Regular sizes are kept in stock and can be shipped promptly:

42 Cubic Feet
104 Cubic Feet
208 Cubic Feet



No. 04134. UNLOADING COAL WITH HUNT GRAB BUCKET AT THE UNITED RAILWAYS & ELECTRIC CO., Baltimore, Md. Height the coal is hoisted, 151 feet.

These capacities are figured liquid full. Bulletin F. I. sent on request.

C. W. HUNT COMPANY

(Established 1872)

OFFICE, 45 BROADWAY, NEW YORK

Works, West New Brighton, N. Y.

CHICAGO: 1616 Fisher Building **SAN FRANCISCO, 865 Monadnock Building**
WASHINGTON, D. C.: Evans Building

Power Transmission Efficiency

ONE of the great advances which has been made of late in the development of mechanical engineering is the appreciation of the interdependence of one portion of an undertaking with every other. Formerly it was not unusual to find the designer satisfied if he had produced a steam engine which was highly economical in its steam consumption, even though its cost for repairs and its burden for interest and depreciation might be excessive. Each portion of a plant was considered by itself, and responsibility ceased at one point only to begin at another.

This was especially true as regards the manufacture and use of power. The boiler was regarded as one unit, for the purpose of generating steam; the engine as another, an apparatus for transforming the expansive force of the steam into the revolutions of the main shaft. From the main shaft all idea of coherence seemed to have been abandoned, and the power was taken off in many directions as the exigencies of the growing plant demanded, using countershafts, pulleys, gears, clutches, etc., as circumstances seemed to indicate. If all worked well, so much the better; if not, the job was tinkered until the trouble was overcome. Any idea as to the efficiency of the power plant as a whole was rarely considered; and, indeed, it was hardly practicable to get at any definite facts upon which performance could be determined.

At the present time a wholly different method is followed. The entire power plant is properly treated as a whole and its efficiency considered as if it were a unit, consisting of a machine into which fuel is fed and out of which comes power at the point of application. Under such a comprehensive view a power system may be considered as composed of three principal elements: the boiler, in which the steam is generated; the engine, in which the steam is employed, and the transmission, by which the power is delivered to the points of application.

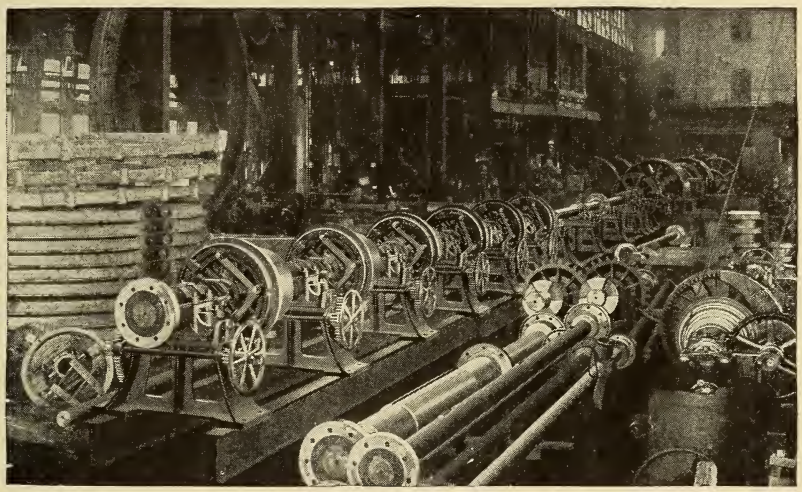
The efficiency of the whole is the continued product of the efficiencies of these elements, and only by keeping each of them up to the maximum can the real value of all be secured.

It is only recently that the third of these elements—the transmission—has received the consideration which it deserves. If its efficiency is to be as high as it can properly be made, it must be considered as a whole, and planned and constructed for the particular place in which it is to be employed and for the especial kind of service to be performed. If, in addition to such definite design, a transmission system, including shafting, pulleys, hangers, bearings, clutches and all details, is assembled and given a critical running test by the maker, it becomes practicable to determine positively just what may be expected of it in actual service. When handled in such a manner, the transmission portion of a power plant becomes a machine in itself, and its possible efficiency may be determined in a manner similar to that of the other elements of the system—the boiler and the engine.

It is an interesting fact to note that almost invariably any attempt to increase the productive capacity of a manufacturing plant by the introduction of modern efficiency methods is met by transmission difficulties, showing that the existing equipment has been practically a growth to serve older conditions, and is incapable of meeting any greater demands until it has been overhauled and improved.

Many years ago the late Robert Briggs maintained that practically all belts were run as slack as they could be, simply because little or no attention was given to them so long as they pulled the machines. In many instances such conditions are true of other things besides belt tensions, and if this state of affairs is to be superseded it must be by the application of true engineering principles to the transmission portion of the plant.

QUALITY **DODGE** SERVICE



Outfit of Shafting, Dodge Friction Clutches, Bearings and Pulleys under running test on our assembling floor

The Factory Power Transmission System Should be a Complete Unit —Properly Designed and Tested

NO satisfactory service would be expected from an engine if the frame was bought here, the cylinder there, the piston and other parts picked up elsewhere and assembled on the ground.

¶ And the outfit which transmits, is as important as the engine that generates the power.

¶ Complete equipments of Dodge Transmission Machinery represent the greatest possible efficiency. Our engineers design Dodge outfits for the particular service which they are to perform.

¶ And, in addition, every special equipment is assembled and put under a running test in our shops. No less a try-out will demonstrate the absolute accuracy of all the parts of the outfit.

¶ Please consider what this kind of tested, established efficiency means in economy of quick erection—how it eliminates friction loss in operation and reduces the expense of renewals and attendance.

¶ If you contemplate the installation of powert ransmission machinery, or if your present power distribution system is uneconomical, write us. We can help you secure efficiency.

¶ Send for our new complete general catalog C-12, "Power Transmission Engineering," and other information on this subject, mentioning Cassier's.

Dodge Manufacturing Company, Mishawaka, Ind.

Branches and Warehouses Carrying Complete Stocks of Dodge Transmission Goods:

New York, Cedar and Washington.
Cincinnati, 126–128 W. Third.
Chicago, 202–214 S. Clinton.
Boston, 137–139 Purchase.
Brooklyn, 37th St. and 2d Ave.
Minneapolis, 202–04 Third St. S.
Pittsburgh, 337 Second Ave.
Atlanta, 54–60 Marietta St.
Philadelphia, 815 Arch St.
St. Louis, 507 N. Main St.

Over 200 Stock-Carrying Agencies in other Leading Trade Centers.

Rock Drill Appreciation

THE beneficent reach of the rock drill is comparable in extent with that of the steam engine itself, although its fame is much less noised abroad. As a striking generalization, it may be said that much less than 1 per cent. of the inhabitants of the earth have ever seen a rock drill, and perhaps not more than 1 per cent. of those who have actually seen a rock drill have come into intimate relations with it, while, on the other hand, perhaps not more than 1 per cent. of all who live on the earth have not had their lives affected, and generally bettered, by this active agency, though to them unknown.

This, of course, it is not possible to prove, but it still is easily credible. Not all are civilized, but where is the savage whom civilization has not touched, and whose habits and whose modes and means of living have not been affected? Then we have only to remember the status of the rock drill in the van of civilization and our opening assertion proves itself.

In the middle of the last century the rock drill began its life-work as the driver of tunnels, and in a short time it became the most facile instrument in all rock cutting, not only in tunnels and mines perforce, but for all exposed work as well, so that it now has a foremost place in engineering operations, the primary and ultimate purpose of all of which seems to be the facilitating of communication and the hastening of the transfers of our products and acquisitions.

While the rock drill works directly in preparing the way for the locomotive and its train, it indirectly does as much for water traffic also. It cuts canals through rock, does subaqueous work to deepen or widen or straighten ship canals, and gets out the stone for piers and docks. All the materials of the steamship and the coal that drives it are got by the rock drill, and members of the rock drill family rivet the plates and frames together. Then the cargo which the steamer carries all in one way or another has been touched by the rock drill, and much of it may be said to be exclusively of rock drill creation, as, for instance, the teeming products of the once arid plains which now have been irrigated through the rock-cut waterways, these rich fruits and other good gifts of the soil going to gladden all the earth.

This is no summary of the work of the rock drill, but only a hint as to one portion of it. The rock drill needs no advocate or promoter. It pushes its way through the world as its bit pierces the rock. Its work grows before it, and the more it does, the more there is for it to do, and especially the greater is the variety of its task, to which it is continually adapting itself by sending out new members of its family with new and special qualifications.

While all in the world reap benefits from the rock drill, and while many, when told of its work, may attain to some appreciation of its beneficence, only those most intimately in touch with it can really know the measure of it as a product of multifarious and untiring ingenuity in the design, of marvelous skill and precision and care in the manufacture and of largeness of enterprise in the commercial handling of it. The manufacture of the rock drill, and of all which the name covers, with that of the air compressor, which gives it life, is one of the world's great industries, which no small and no unexperienced organization can be expected to competently handle. The speed and inertia of the latest steamship are typical of that of the modern manufacturing establishment, and the size of either is a function of success.

We have thus one more instance of the manner in which engineering methods and appliances are entering into all the affairs of daily life, not only in matters readily perceived, but even to a greater extent in things which we cannot directly connect until pointed out.

Minimize Your Rock Drilling Costs

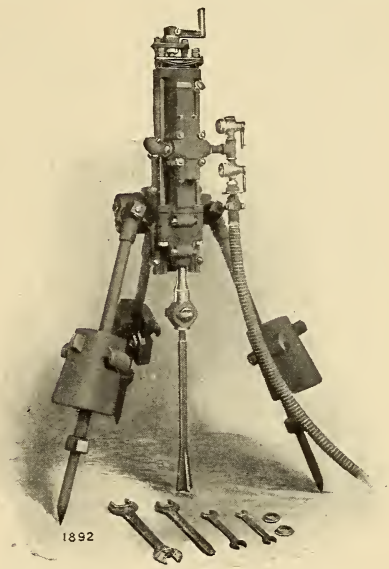


Figure the items in your rock drilling costs. There is power to run the drills—labor to operate them—repairs to keep them on the job. These make up cost of drilling.

POWER: Take no manufacturer's test figures for air or steam consumption, but **choose the drill that has everywhere shown that it uses less power per foot of hole drilled than any other.**

LABOR: You pay your drill runner by the day. How much he drills depends upon the drill he uses. **The rock drill with the largest footage capacity per hour, or per day, or per month, is the drill you want.**

REPAIRS: A drill out of commission for repair or overhauling is a dead loss. **You want the drill that is "always on the job" because it is built to stand the hardest work.**

Ingersoll-Rand Rock Drills meet these three fundamental requirements. The best proof is the fact that more of them are in use, in contract, mine and quarry work, than of all others combined.

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Offices in All Principal Cities of the World

COMPRESSORS ROCK DRILLS COAL CUTTERS PNEUMATIC TOOLS

Real Steel

THE term steel has always been associated with the idea of strength and of resistance to abrasion and shock, and this idea is wholly correct. It is not so generally understood, however, that much which passes for steel is really only partially real steel, and that much of its volume is composed of impurities, and even of bubbles of air and other gases, occluded within the mass of metal, and acting to reduce its valuable properties.

When we examine a sponge we can see that it is porous, and that only a portion of its volume is composed of solid material, much of the space which it occupies being filled only with air, so that we can compress it into a much smaller volume than it ordinarily requires simply by the application of the pressure of the hand. It does not always appear, however, in the case of a solid metal, such as steel, that the interior of the mass may contain gas bubbles and particles of slag, and it is only when a critical and scientific examination is made that the real structure appears.

We know that carbon in steel gives it certain properties, such as capability for hardening under proper heat treatment; but the presence of carbon alone does not insure the absence of injurious particles of slag or of weakening bubbles and spaces occupied by air or gases instead of solid metal. The only way in which the absence of such deteriorating conditions can be assured is by the use of some other element than carbon, some substance which will not only draw the solid impurities into the slag, but also combine with the occluded gases and draw them out, to be replaced by solid and homogeneous steel.

When it was first discovered that certain elements, such as titanium, could thus be used to purify and solidify steel and insure the homogenous quality of the product, it was regarded by manufacturers as an effort of the scientific chemist which was not altogether practicable, commercially, for the use of the steel manufacturer. The metallurgist, however, has overcome any such objections by the production of the ferro-alloy, furnishing a compound of the desired element in large proportion united with iron, so that the addition of a small determinate proportion of the alloy will enable the steel maker or foundryman to make the desired alloy steel without requiring any especial chemical or metallurgical ability.

Thus, in the manufacture of open-hearth steel, the titanium alloy is shoveled directly into the ladle as the metal is poured from the furnace, while in the case of Bessemer steel the alloy is added in the ladle after the "blow." In making titanium iron castings the titanium alloy is added with the charge in the cupola, the amount added being in all cases proportioned to the desired constitution of the final product. The operation of making steel or iron under such a process is as simple as that of producing the ordinary metal, while the presence of the titanium removes the impurities and leaves it homogeneous in constitution and close and uniform in grain.

In meeting the modern demand for material of construction which shall unite reliability with maximum strength, it is necessary to know definitely just what is being furnished, and the presence of flaws or blow holes hidden in the interior of the mass, and revealed only after the disastrous breakdown has occurred, cannot be tolerated. By the use of a purifying and cleansing alloy, such as is made possible by the introduction of titanium, the metal has its impurities washed out of it, and the real value of the steel is assured.

It is by the use of such improved materials that the modern demands of the engineer and the constructor must be met by the chemist and metallurgist, greater strength and endurance being obtained by true scientific methods.

It Will Pay to Insist That Your Steel Maker Use Titanium Alloy

—because then your steel will be all that good steel should be

THE strength of steel, its resistance to abrasion and corrosion, its ductility — all its good qualities — are materially reduced by impurities. It is entirely possible for a sample piece of steel to appear absolutely sound so far as external appearances and the usual tests show—but the rest of the metal may really be rotten with slag and gas bubbles.

These facts are well known by users of iron and steel who are now insisting that their metal be purified and strengthened by Titanium Alloy. They know that every piece of Titanium Steel and Iron is sound all through, and can be depended upon absolutely.

TITANIUM

The Wonder-Working Alloy

—frees steel from harmful impurities

Titanium Alloy produces its good effects by chemically combining with the impurities and carrying them off with the slag. That it does this more effectively than any other alloy (and at less cost) has been proved time and again in actual practice and by the experiments of leading chemical and metallurgical authorities.

The wearing or enduring quality of steel treated with Titanium Alloy is really remarkable. This is because the removal of the impurities leaves the metal more homogeneous and powerful enough to resist the most unusual stresses. The closer grain of the metal also makes it more impervious to water and corrosive agents.

Titanium Alloy is so cheap and so easy to use that any steel and iron maker can furnish you with Titanium Steel and Iron at an extra cost for steel of about $2.00 per gross ton—for iron, 75 cents and upwards per ton.

Send for Booklet No. 31, containing facts, figures and statements from men who know and value Titanium Alloy.

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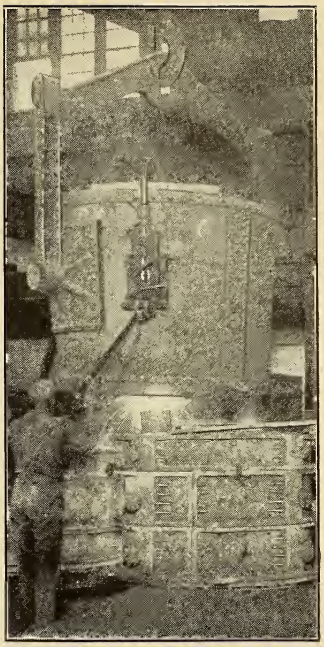

Pouring Titanium Steel From Ladle Into Mold

(Photograph by Courtesy of Penn Steel Castings and Machine Co., Chester, Pa.)

In making open hearth steel Titanium Alloy is shoveled into the ladle as the metal pours from the furnace. In Bessemer steel the alloy is added in the ladle after the "blow." In iron casting work Titanium Alloy is added with the charge to be melted down.

Read These Two Authoritative Statements

"Titanium introduced as an alloy at once combines with the gaseous nitrogen present in the molten metal, forming a stable nitride. It is the formation of this stable nitride which prevents blow holes and thereby produces solid ingots or castings." —DR. F. C. WEBER.

"The treatment of all steels with ferro-titanium for the purpose of purifying the metal is strongly recommended. The presence of nitrogen to the extent of .02 to .035 or .045 in certain steels being enough to cause the metal to break asunder, destroying all elongation and reduction of area."

H. LE CHATELLIER,
Prof. of Metallurgy,
University of France.

To Makers of Steel and Iron

We would suggest that you begin getting ready for orders of Titanium Steel and Iron. Booklet No. 31 will interest you from start to finish.

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President Chelsea Exchange Bank

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FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

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SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor

CHARLES EASTON, Financial Editor.

The Situation

AFTER making a thorough canvass through channels available to this magazine, we find that business sentiment throughout the country is decidedly hopeful, and the belief prevails that conditions will not only hold firm during the next few months, but improve and acquire sufficient momentum for a more rapid advance later in the year. There are many logical reasons for this optimistic view, but the principal one is that large users of manufactured products have for the past few years been buying conservatively and only as their needs absolutely demanded. Consequently, there is little surplus material accumulated, either on the shelves of merchants or in the storehouses of railroads and industrial institutions. The increased buying demand that recently developed on the part of railroads was the result of present needs, and did not include purchases for reserve account.

Many developments of the past month are significant of a steady expansion in business, prominent among which were the monthly report of the Copper Producers' Association, showing a big reduction in surplus copper stocks of the United States; the Government cotton ginning report, indicating the largest amount of cotton ginned up to the 1st of January in the history of the country, and the United States Steel Corporation announcing another large increase of unfilled orders.

Reports from Europe indicate that trade conditions there are also much improved. There is apparently a pronounced recovery in Germany from the recent depression, and increased activity in France since cordial relations have been established with Germany, through the settlement of the Moroccan trouble. It now appears that political issues bearing upon the industrial activities of the United States will be settled with less friction than was expected. This is due, in a large measure, to the fact that the common sense of the common people is asserting itself, as it always does at the right time and in the right way, by demanding a cessation of the ravings of self-seeking reformers, and at the same time forcing a discontinuance of the arrogant and unscrupulous methods of those in control of certain large corporations. Common sense and common justice, as administered by the American people, always have met and always will meet every political and commercial crisis of this country. They constitute a court of last resort,

before whom both political and commercial leaders must, sooner or later, appear to establish the merit of their theories and methods, and under the positive rulings of this tribunal no culprit can refuse to answer simply on "the advice of counsel." Credit is given where credit is due alike to the statesman and business man who have honestly laboured to benefit mankind by their consistent, persistent and insistent efforts to improve and perfect our business and political conditions.

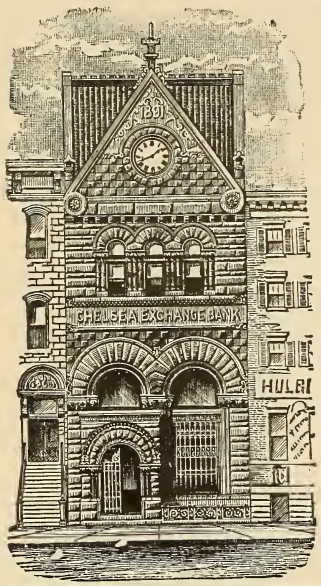
Owing to important economies resulting from standardization of design and improved methods of manufacture, the C. W. Hunt Company, West New Brighton, N. Y., announce a reduction in selling prices, while maintaining the well-known high standard of their machinery, both in design and quality of material and workmanship.

It is marvelous to note the quantity of Northern and Eastern capital that is going into Southern States for the development of traffic and agricultural resources. This is especially noticeable in the Rio Grande valley and Texas coast section. The 'Frisco Railroad system has left nothing undone to further interest in this particular section, with the result that land values are advancing very rapidly, and splendid opportunities for profitable investment are being created.

The McAdoo tunnels between New York and New Jersey are, for the first time in their history, earning their fixed charges. This is due to the increase in fare from five to seven cents.

The total output of iron ore of the ten principal countries engaged in the industry in 1909 exceeded 125,000,000 tons.

In the heart of the New Business Centre of the U.S.



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OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

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A Continually Growing Bank in a Continually Growing District

Question—What do you think of Bethlehem steel?

Answer—The revival of the iron industry should greatly increase the intrinsic value and speculative possibilities of Bethlehem steel. Its prospects are good.

The Canadian Pacific has announced, through its vice-president, Mr. Bury, that $20,000,000 will be spent for improvements and betterments on its lines west of the Great Lakes. In its congested sections the main line will be double-tracked, and, in addition, about 250 miles are to be relaid with 80-pound standard rails.

It is an interesting fact that the Ontario Power Company sells power in Canada at $9.40 per horse-power, while the same power is sold on the American side at $25 per horse-power.

Question—In what way can the stockholders of Allis-Chalmers protect their interests without contributing new capital?

Answer—Our information on the subject would indicate that there is no way for a stockholder to protect his interests except by contributing new capital. In the tentative plan now being considered, $6,000,000 has been estimated as the probable amount of new capital necessary, and it is to be represented by the issue of 5 per cent. bonds.

It is reported that the Steel Corporation will increase its open-hearth capacity by building an open-hearth plant on the Edgar Thompson mill. Steel prices have held their advance made during the past three weeks, and increased tonnage continues to come to the Steel Corporation. January will show in the neighbourhood of 300,000 tons increase in orders.

Our foreign trade for 1911 will show an excess of exports over imports of $559,441,280—a larger excess than in any year since 1908. This is one of the most favourable factors of the business situation.

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The New York Central Railroad has just completed a notable series of financial transactions, and apparently it will not have to resort to the necessity of issuing short-term notes. It has purchased control of the Ontario & Western by handling New Haven debentures in the amount of $13,000,000, interest on which will be offset by a 2 per cent. dividend on the purchased stock. It has also issued $35,000,000 worth of 4 per cent. debentures in payment for the stock of the New York & Harlem, and within the past two years the Central acquired from the Vanderbilt estate the stock of the Spuyten Duyvil & Port Morris. This company's five miles of road between Spuyten Duyvil and Mott Haven Junction is the link between the main line on the Hudson River and the New York & Harlem, which alone reaches the Forty-second street terminal.

Question—Would you advise the purchase of listed securities on margin for speculative purposes at this time?

Answer—We do not advise the purchase of listed or any other securities on margin for speculative purposes. Marginal trading is especially dangerous for the man of small means.

The Western Union Telegraph Company has notified holders of its $8,000,000 worth of convertible 4 per cent. bonds, due in 1936, that it will exercise its option of redeeming them on May 1, at 105. This will release $9,733,100 worth of stock to the New York Telephone Company pledged as collateral for the bonds.

"Reads like fiction, but it's a fact," according to the recent real estate market letter issued by the Debenture Corporation of New York, that the streets of Greater New York have a mileage of 3,740, or just the distance between here and London. There are 444 miles of water-front included in this port. Beneath the pavements of Greater New York

there is $12,000,000 invested in copper wire. There are 2,500,000 trees in the city parks, 10,000,000 tons of food every day are consumed by the inhabitants of the city. The town boasts of 100 theatres, 1,300 churches and 10,000 saloons; 215 respectable hotels, with 52,577 rooms, and 41,925 servants. The municipality spends $1,206,815 for forage and horse-shoeing.

The American Infusion Steel Process Company have opened their new plant at the Bush Terminal, Brooklyn, N. Y., which has a daily capacity of 8 tons of their scientific steel hardening compound "Stelpro."

It is reported on good authority that during the past few weeks over 4,000 idle coke ovens have been ordered into blast, but have been unable to get to their productive capacity because of a shortage of labour and the cold weather.

Question—Would you advise selling Wabash common?

Answer—While it is a foregone conclusion that Wabash common will be subjected to an assessment, yet we do not feel disposed to advise its sale. We suggest holding until reorganization plans are further matured.

The Florida East Coast Railway, owned and built by H. M. Flagler, containing 582 miles, running from Jacksonville to Key West, Fla., has been completed, and the first train passed over it Sunday, January 21. Mr. Flagler has spent to date about $50,000,000 on this pet enterprise and improvements incidental thereto.

The Monarch Typewriter Company, the Remington Typewriter Company and the Smith Premier Typewriter Company are now in process of consolidation, and will all have their headquarters in the near future at 327 Broadway, under the name of the New Remington Typewriter Company.

How to Forcast Business and Investment Conditions

A KEY TO FINANCIAL SUCCESS

By Frank Crowell

SUPPOSE you could sit by your evening lamp to-night and have a heart-to-heart talk with a successful investor and business man of 30 years' experience, who had accumulated a comfortable fortune by his foresight and knowledge of conditions.

Suppose he were to tell you in simple, straightforward language just the principles and methods which had enabled him to analyze the business and investment situation, and to make large profits in stocks, bonds and real estate, on moderate capital.

Would you do it?

Frank Crowell is such a man. And he has done exactly this thing.

He has taken the period from one great business panic to the next—usually about 20 years, varying according to circumstances—and has analyzed it year by year, showing not only the plain indications which predict the condition of business and of investment markets for the immediate future at any time, but also the causes which lie underneath those indications.

The book was completed in July, 1910, and the predictions of the author for 1911 have been fulfilled in a truly remarkable manner.

Contents: I. Some Fundamental Conceptions. II. Beginning the Twenty-Year Cycle. III. Labor Better Employed and Prices Rising. IV. Good Times. V. Public Demand for Stocks. VI. Era of Stock Speculation to Securities Panic. VII. After Securities Panic to Excessive Prosperity. VIII. Excessive Prosperity to Waning of Stock Boom. IX. Latter Part of Boom Period. X. Stock Boom Ends First—Business Now Affected. XI. Business Declining. XII. In the Shadow of the Panic. XIII. The Commercial Panic. XIV. Depression Following Commercial Panic.

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A Modern Submarine Chart with Two Hundred Parts Numbered and Named

BELOW is a reduced-size illustration of a submarine chart, which has just been published. This cross-section view shows clearly and distinctly all the interior of a submarine of the latest type.

This chart, which has been approved by naval engineers, is 14 x 28 inches, printed on plate paper, and is absolutely correct in every respect, no details having been omitted, and from its study one can obtain more information about the construction and operation of a modern submarine than in any other way.

This chart is really an encyclopedia of a submarine, and its educational value is worth many times its cost.

We mention briefly some of the features shown in the engraving: The bow torpedo-launching tube and all its operating and controlling mechanism. All automatic devices known for the prevention of accidents. The complete propelling and steering machinery. Air pumps and storage flasks for under-water breathing. All the delicate mechanical means for making observations above the water when the boat is submerged, and for the determining the exact depth under the water. Storage battery outfit, mine, fuel oil, ballast and adjusting tanks—in fact, all the machinery and devices fitted in a modern submarine boat. To make the

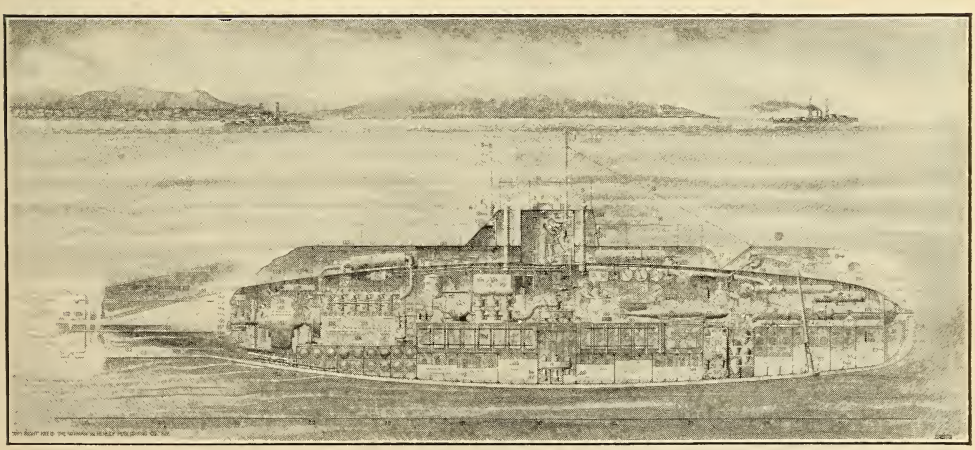
(Continued on Page 82)

New Plant of American Infusion Steel Process Company

The American Infusion Steel Process Company's new plant, located in the Bush Terminal, Brooklyn, New York, consists of two complete departments, one for manufacturing their infusing compound "Stelpro," the other for treating manufactured articles of steel by infusion with "Stelpro."

The manufacturing plant consists of bins for storing rough and ground stock, mills for grinding, automatic weighing apparatus for mixing the several ingredients in exact proportion, pulverizing mills, elevators for transferring the material through the several stages of manufacture. Bins and elevators are of steel, and all apparatus is driven by electric motors, seven of which employ from 3 to 15 horse-power.

The treating plant consists of two 48-inch, two 36-inch, two 28½-inch and three 18-inch fuel oil furnaces. Two other special furnaces are to be installed at once. Ample quenching tanks with running water, also oil tank with cooling apparatus, through which the oil is continually circulated to maintain constant temperature. A very complete pyrometer outfit has been installed, also overhead tramways and specially designed trucks for handling both hot and cold material.



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A Modern Submarine Chart

(Continued from Page 81)

engraving more readily understood, all the features are shown in operative form, with officers and men in the act of performing the duties assigned to them in service conditions.

The regular price of this chart is 25 cents; but the publishers of CASSIER'S MAGAZINE have made a special arrangement with the publisher whereby, for a limited time, it will be supplied free of expense to all new subscribers or renewal for two years to CASSIER'S MAGAZINE, or the chart and a seven months' trial subscription will be sent for one dollar and a half, sending both chart and magazine to one address or to separate addresses, as may be desired. Orders should be sent direct to the Cassier Magazine Company, 12 West Thirty-first street, New York.

The Modern Master-Smith

We are all familiar with the old-time legends of the master-smith, who, by his skill at the forge, was able to produce for the hero of the tale a weapon which should cut through the armour of giant or wizard and maintain its temper and edge against all tests.

The modern industrial captain has to cut his way also through metal, and one of the notable achievements of the engineer and metallurgist has been his success in the production of steels of hardness and cutting capacity which altogether surpass the finest work of the legendary sword-maker.

Not content with the manufacture of tool steel of hardness, high-speed cutting capacity and exquisite temper, the modern master smith has now produced a method of converting soft iron or low-grade steel into tool-steel of the highest grade simply by the infusion of the necessary proportion of carbon and other elements by contact and proper heat treatment, so that keen-edged chisels may be made from railroad spikes and machine cutters from soft and

(Continued on Page 84)

BOOK NOTES

The Problem of Flight

The Problem of Flight. By Herbert Chatley. Published by J. B. Lippincott Co. 132 octavo pages, 61 illustrations; cloth. Price, $3.50 net.

In view of the fact that we now appear to be on the verge of a practical solution to this classic problem of flight, the author begs to submit to the engineering profession an epitome of the knowledge at present available on the subject. In the mathematical consideration he has adopted the principle, well established in engineering practice, of omitting those factors which appear to be unimportant. The formulæ are, therefore, "engineering formulæ" in the strict sense of the word—i. e., they are not the result of a deep mathematical analysis, which it is, in most cases, impossible to apply. There are over sixty illustrations and diagrams in the text, which clearly demonstrate the problems set forth.

Selection and Proportion of Aggregates for Concrete

Selection and Proportion of Aggregates for Concrete, by Albert Moyer, Assec., Member A. S. C. E. Third edition with much new matter.

The object of this article is to give a practical method which will enable any concrete constructor to make economical use of the best aggregates, so proportioning them as to give the maximum strength and density with a minimum amount of cement. Concrete under discussion is plain and not reinforced; for reinforced concrete an over-cemented mixture is sometimes necessary, particularly in column construction.

The pamphlet contains much valuable information to concrete users, and a copy of the book may be obtained free by addressing the Vulcanite Portland Cement Company, Fifth Avenue building, New York, and mentioning CASSIER'S MAGAZINE.

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PERSONALS

Mr. Alfred J. Thompson, vice-president of the American Infusion Steel Process Company, New York, recently received the report of the Bureau of Ordnance at Washington concerning the tests made by the Bureau of a milling cutter and chisel, which states: "The infusion-treated samples from the tests appear superior to any hardening process in use at the Naval Gun Factory."

Mr. Harry G. Stoddard, formerly manager of the Washburn & Moen branch of the American Steel & Wire Company, and for the past seven years president of the Trenton Iron Company, has become associated with the Wyman & Gordon Company, of Worcester, Mass., as vice-president and general sales manager, to which position he brings an exceedingly wide experience in the steel business.

Mr. Chas. M. Lyle, for several years with Manning, Maxwell & Moore, in charge of their Southwestern territory, with headquarters in St. Louis, has resigned, to accept the management of the St. Louis office of the Niles-Bement-Pond Company, whose offices are at 516 North Third street.

Mr. W. L. Keller, of Kearney, Neb., has recently obtained five patents on cement blocks, block machines, fence-post moulds, staple anchors and concrete mixers.

These patents have been spoken of very highly, and Mr. Keller desires to sell them to manufacturers, and will be glad to give information concerning them.

Mr. Herman Frasch, the inventor of the process for mining sulphur by melting it underground with steam and pumping it to the surface, was recently presented with the Perkin Medal, in recognition of the great value of his invention, by the Society of Chemical Industry.

By this process the sulphur beds of Louisiana, which could not be worked under former methods, are now yielding 500,000 tons a year, and are in absolute control of the American market, which had been previously monopolized by British concerns in Sicily.

This invention made the production of sulphur in Louisiana far cheaper than in Sicily, although the average of wages paid there is only 60 cents a day. Hundreds of thousands of labourers are employed in the Sicilian sulphur mines, and, in order to avoid a competition which would throw them out of employment, it is asserted, the Union Sulphur Company, which controls the Louisiana sulphur, made an agreement eight years ago with the Italian Government under which the American company bound itself to refrain from invading the European market.

It is said that Mr. Frasch's invention has reduced the cost of producing sulphur to $6 a ton.

The Modern Master-Smith

(Continued from Page 82)

inexpensive steel.

Trials of cutting tools made by the American Infusion Steel Process Co. by their Infusion Process at the Ordnance Bureau of the United States Navy Department have given such remarkable results, both as to cutting speed and endurance, that the chief of the Bureau says: "From the test of the infusion-treated samples, it appears superior to any hardening process now in use at the Naval Gun Factory," so that the modern master-smith has outstripped the fabled tales of the wizard weapon-maker of mediæval times.

REDUCING POWER COSTS

By G. Reth

COMPARATIVELY few managers and superintendents who have steam boilers under their charge have ever made an analysis of their power costs, and, if so, have looked upon the expense of boiler maintenance, due to bad water, as a necessary evil, or because they have been operating with water from the same supply for many years believe they have no particular need for any improvement in that direction worth considering.

WE-FU-GO SYSTEM OF WATER SOFTENING AND FILTRATION

That scale and corrosion resulting from the impurities in the water used for boiler feed are a considerable factor in the cost of boiler maintenance cannot be questioned. Such items as extra fuel, boiler cleaning, compounds, reduced service efficiency, repairs, tube-cleaning machinery and the power required for operating it, etc., are contingent upon scale and corrosion.

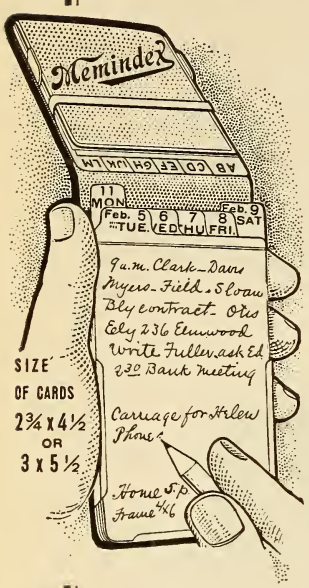
The ideal boiler conditions can only be maintained with clear, soft water. Everyone is probably familiar with some boiler plant having a natural supply, with which the boilers are operated year in and year out without scale or corrosion. The steam conditions are ideal, and on the water side the feed-water heater is clean. The pump and pipe lines do not show any signs of scale and corrosion, and all of the apparatus is in condition to be operated at maximum efficiency without expensive repairs. Natural supplies of water that give the ideal results in the steam plant are not common, and the contrast between operating ex-

lines of work, a filing tray and a

(Contiuued on Page 88)

MEMINDEX

An Engineering Aid



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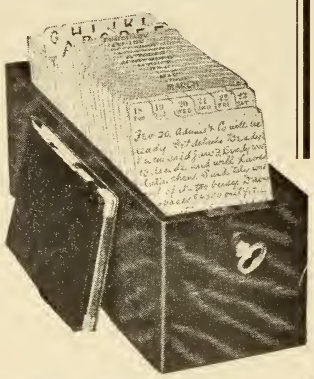

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Keeping Track of Coming Events

(Continued from Page 63)

handsome pocket-case for carrying the cards, so designed that it always opens at the right place. By this device you don't have to turn over the pages to find to-day's requirements, as they are always at the front; and, further, the memindex can be quickly consulted with only one hand free, and that gloved.

By the use of this arrangement matters for to-day, matters for the future, no matter how near or how far off, are brought to your attention at just the proper time, and require no attention on your part until that time, your mind being relieved of all details and left for larger matters.

In fact, the memindex right in your pocket provides a card for every day and extra ones for special purposes, while its pocket-case is stiff enough so as to enable easy writing when held in the hand, while the filing tray proves a mine of usefulness, providing, as it does, a means of filing data according to date, by subject or alphabetically, as you may desire; and it will prove, further, a watch-dog which will remind you to refer to it at the right time.

If you can save, on an average, ten minutes in each working hour of the day, it means to you, as far as effective working time is concerned, one extra day each week—that is, 52 extra days a year—for your work without the expenditure of any more time and less physical and mental effort. That sounds worth while and rather attractive, does it not? Yet that is what the memindex will aid you to accomplish.

Mr. E. L. Hubbard, of the Panama Railroad Company, recently stated that "it is interesting, in their cabinet meetings, to see the heads of departments lined up with memindex books," which is only one example of the esteem this simple little self-helper is held in.

The memindex is manufactured by the Wilson Memindex Company, of Rochester, N. Y., and will be found

of great service to engineers, architects, advertising managers, publishers, accountants, sales managers, superintendents, treasurers, etc. — in fact, to professional and business men in all lines of work, adding, as it does, much in efficiency and saving much in care and mental work on the part of the user by enabling him to keep track of future events with little or no trouble.

Why We Must Have Potash

Last year American farmers bought from Germany about $15,000,000 worth of potash salts. In 1910 $12,000,000 worth; in 1900, about $4,00,000 worth. During these twelve years we spent for potash $75,000,000, and during the coming twelve years, at the present rate of increase in consumption, we shall spend $425,000,000 more. While this possible increased demand for potash is enormous, it is by no means improbable. We are really just beginning to recognize widely the great value of potash as a fertilizer. The possibilities of its use in the United States are almost limitless. We are importing all this potash, and it goes against the American grain to send abroad our good money for a raw material, especially a mineral, for we pride ourselves on being by far the greatest mining producers of the world.

It is well worth while, therefore, to find an American supply of potash. As a matter of fact, we must either purchase potash or produce it, since potash is an absolute essential constituent of any complete fertilizer. The period of virgin soil requiring no fertilizer, and of woodashes' supply, has gone by in the United States, and it is becoming more and more generally necessary to apply potash salts in common agricultural practice. Without potash in the soil no plant can grow, much less thrive and reproduce itself.— Guy Elliott Mitchell, in the *American Review of Reviews.*

LAUGHLIN
Safety Self Filler
Fountain Pen

Cut Showing Barrell Drawn Apart Exposing Pressure Bar, Ready for Refilling

Guaranteed absolutely non-leakable—pen and feed kept moist and primed, insuring a free, uniform flow of ink instantly upon contact with writing sheet.

May be carried in any position in pocket or bag without possibility of leaking or sweating.

Every pen guaranteed satisfactory to the user or money refunded. Size illustrated in this advertisement **$2.00** by mail prepaid to any address, plain black chased or mottled as desired.

It is not necessary to write us a letter; simply pin a $2.00 bill to a slip of paper containing your name and address and we will mail the pen by return mail.

Send us the name of your dealer,

that you asked to show you a LAUGHLIN Nonleakable Self-Filling Fountain Pen, and we will send you FREE OF CHARGE one of our new Safety Pocket Fountain Pen Holders.

It is not required that you purchase a pen to get this Safety Holder. We simply want the names of dealers who do not handle this pen that we may mail them our catalogue.

We will appreciate this favor very highly.

Address,

Laughlin Mfg. Co.
797 Griswold Street
Detroit, Mich.

(Continued from Page 85)

penses on a non-scaling and non-corroding feed water and one that causes either of these troubles is such that it would seem that no doubt could be entertained by the steam user as to the logical course to take with respect to approximating the ideal conditions.

Make-shift devices only add to the power cost. Cleaning is expensive and only periodic, the boilers scaling as soon as put into service after each cleaning. Boiler compounds do not remove impurities from the water, but rather increase the amount of impurity in the boiler, making them expensive to use, not taking into consideration their exorbitant first cost. Tube-cleaning machinery, while thoroughly rational, is absolutely unnecessary, when proper means are employed to purify the water fed into the boilers. Feed-water heaters used as purifiers, with or without the aid of chemicals (the so-called hot process systems), is merely a make-shift, since as its efficiency as a purifier increases, its efficiency as a heater deminishes. The mere fact that scale is deposited in the heater (and in the water pipe lines leading from it) does not justify its being called a purifier any more than to call the boiler a purifier because scale deposits in it, and the fact that the heater must be cleaned must not be overlooked.

The most economical and efficient boiler operation is only obtained with a soft, clear, non-corroding feed water; therefore, the problem for the steam user having a bad feed water is simply that of softening, purifying and clarifying it before it goes into either heater or boiler.

The process of the softening and purification of water is thoroughly rational, has been tried out in hundreds of plants, and some of the largest steam users in the United States have installed system after system.

One of the systems which has demonstrated the efficiency of this process (thirty installations of which have been made for one company, which, without doubt, is one of the largest steam users in the United States) is the We-Fu-Go system. This system is of the intermittent type, in which definite quantities of water are treated all the time, and, after treatment, final clarification is effected by filtration through filters, as is shown in the accompanying illustration. It is manufactured by Wm. B. Scaife & Sons Company, of Pittsburg, Pa., who also manufacture all types of pressure and gravity filters, as well as all types of continuous water-softening and purifying systems for every industrial use.

The next triple convention of the American Supply and Machinery Manufacturers' Association, National Supply and Machinery Dealers' Association and Southern Supply and Machinery Dealers' Association will be held at Norfolk, Va., on Monday, Tuesday and Wednesday, May 13, 14 and 15, 1912.

THE WE-FU-GO SYSTEM
Patented

WATER

Softening
or
Filtration

FOR BOILER FEED AND ALL INDUSTRIAL USES

Wm. B. Scaife & Sons Co.
Pittsburgh, Pa.

THE LATEST CATALOGUES

Rock Drills

"Rock Drills": a 16-page, 6 x 9, bulletin form 4204, issued by Ingersoll-Rand Company, 11 Broadway, New York City, descriptive of "Arc Valve" tappet rock drill. This drill has an arc-shaped valve, which is moved on a circular seat by a rocking tappet, the sliding surfaces all being concentric with the rocker pin. The working pressure is on the back of the valve, forcing it to its seat. The valve is moved by the piston through an intermediate tappet or rocker. This tappet swings on a pin and extends slightly into the cylinder bore, where it is moved by beveled shoulders on the piston sliding under it. An arm on the tappet carries a spring and plunger engaging the valve. The positive quality of the valve movement in this drill renders it peculiarly useful when steam is used and when water of condensation is likely to be encountered. Catalogue shows sectional views of drill, and also gives list of duplicate parts, together with descriptive table of sizes and capacities.

Bearings

"SKF Radial Bearings" is the title of a bulletin just issued by the S. K. F. Ball Bearing Company, 50 Church street, New York. This bulletin explains the construction peculiarities, particularly the provision for self-alignment, of SKF radial bearings, and gives dimensions, speeds and capacities of the principal types and sizes.

Roofs

The Barrett Manufacturing Company, 17 Battery place, New York, N. Y., have recently issued several unique and interesting booklets descriptive of their Barrett specification roofs, which have proved so economical in service and are so largely used. Copies may be obtained by addressing them.

Modern Roads

"Modern Roads; Their Construction and Maintenance," is a handsome book of 40 pages issued by the Barrett Manufacturing Company, 17 Battery place, New York, N. Y. A copy will be sent on request to those writing them and mentioning CASSIER'S MAGAZINE. Another new publication of this same company is entitled "How a Tarria-Macadam Roadway is Constructed," and may also be obtained free from them.

Among other new catalogues recently received are "Chicago Pneumatic Tandem Gasoline-Driven Compressors," issued by the Chicago Pneumatic Tool Company, 50 Church street, New York; "Stevedore Rope Manufacture," by the C. W. Hunt Company, 45 Broadway, New York; "Mechanical Lubrication," describing the improved Sterling lubricators built by the Sterling Machine Company, Norwich, Conn., which will prove most instructive, as it describes some of the features of its construction which display a ruggedness and simplicity of design; "Alternating Current Water-wheel Generators," built by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa.; "Multi-jet Eductor Condenser," from Schutte & Koerting Company, Philadelphia, Pa.; "Di-elite Resistance Units," the Wirt-Electric Specialty Company, Germantown, Pa.

Any of these publications will be sent on request to those writing the company issuing them and mentioning CASSIER'S MAGAZINE.

Uncle Sam's Steel-Cutting Methods

Some remarkable results have recently been obtained by the Bureau of Ordnance of the United States Navy Department with cutting tools produced by a new and interesting process. Instead of making the tool from high-cost tool steel, containing the carbon and other elements in its entire mass, the new tools are made of soft steel, easily shaped into the

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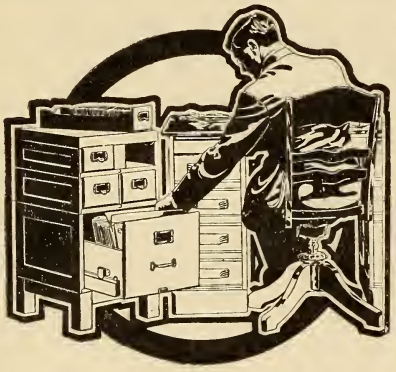

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Scientific Management in the Office, a little booklet we have just issued, describes briefly the scope of Efficiency Methods for the Office, and points out some of the channels through which time is wasted and money lost.

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proper form, and then treated by the so-called "infusion" process, the carbon and other elements being placed in contact with the metal in the form of a special powder and subjected to a heat treatment which causes the soft steel to become hardened to such a depth as to convert it into cutting material even superior to the far more costly tool steel.

The tests at the Ordnance Bureau showed that milling cutters made by the infusion process cut deeper, faster and further than tools made of the best carbon tool steel, and fully as well as cutters made from modern high-speed tool steel of far higher cost. The chief of the Bureau says that the infusion process "appears superior to any hardening process now in use at the Naval Gun Factory," so that it appears that we are now in possession of a method of making tools of the highest grade for cutting metal out of ordinary soft steel.

Norton Alundum Refractories

The properties of these refractories are high melting point—approximately 2,000 degrees Cent., 3,600 degrees Fahr.—high thermal conductivity, non-conductors of electricity, resistance to changes of temperature, chemical inactivity, variable porosity and high mechanical strength. These refractories are made from an electric furnace product, alundum being made by fusing the mineral bauxite in the electric furnace and is practically pure fused alumina.

The crude alundum comes from the electric furnace in large ingots weighing about 5 tons each. It is crushed to grain of various sizes and carried through several refining operations before it is ready for mixing with the bonding materials.

After the refractory articles have been shaped, they are fired at a high temperature.

This product is manufactured by the Norton Company, Worcester, Mass., and made into electric furnace parts, such as cores, tubes, muffles, and also into crucibles for laboratory use and combustion boats, filters, etc.

ADDING TO THE VALUE OF SHEET-METAL SCRAP

By Washburn Francis

IN any plant where scrap from sheet iron, such as is used in the manufacture of electric motors, accumulates, it can be made worth in the neighbourhood of $6 more per ton by compressing it into bales, due to the saving in labour cost when so baled.

The illustrations shown below are of a type of press and its operating system recently designed for this purpose by the Watson-Stillman Company, of New York, and installed by the General Electric Company. This type of press takes the scrap metal from the floor, compresses it, pushes the bale out and drops it beneath the floor onto a runway, from the end of which the bale can be dumped onto an elevator, from which, in turn, it can be put onto another runway and delivered onto a freight car.

The economy of this method of baling scrap will be seen when it is understood that, with suitable pump and accumulator service, this press forms from 15 to 25 bales—about 2 to 3 tons of material—per hour, the output depending upon the skill of the operator.

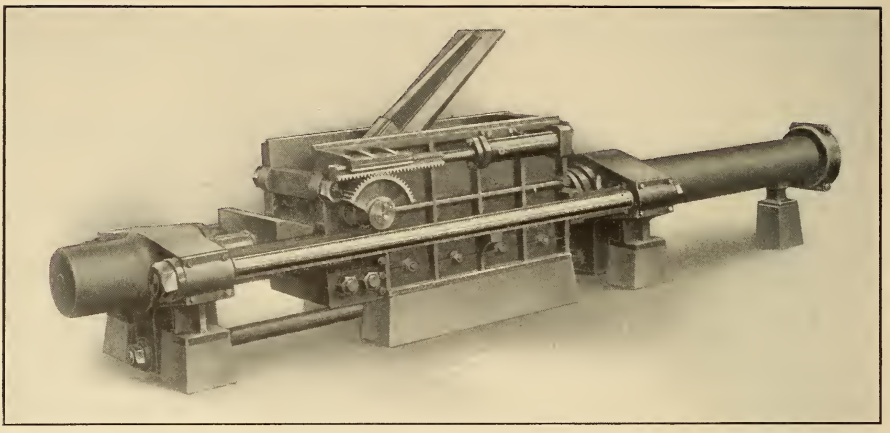
The press is approximately 23 feet long, 4½ feet wide, 4¼ feet deep, is set in a pit about 6 feet deep and 30 feet long, and rests on pedestals, to give room for repairs, if necessary. The working parts consist of (1) a scrap or pressing box, the top of which is flush with the operating floor line, and which has hydraulically-operated cover, and (2) two opposed hydraulic cylinders. One of these closes the box and the other compresses the bale and pushes it out.

The pressing box is 60 inches long by 20 inches wide by 30 inches deep, which depth is reduced to 10 inches by the closing of the cover. The larger of the cylinders (at the left in the picture) closes the front end of the press, at the same time acts as a lock to the cover when it is closed, and is controlled by the same valve as the main or compressing cylinder (at the right). The compressing cylinder is double-acting.

Pressure is supplied to the closing cylinder and the working end of the compressing cylinder from a variable pressure, belted hydraulic pump. This pump has large pistons, which deliver up to 1,500 pounds per square inch, and are automatically cut out of action by the smaller ones as the pressure goes above the figure named, and continue in operation until a maximum of 4,900 pounds per square inch is reached. At the instant of highest compression the pump has a maximum requirement of about 40 horse-power.

Pressure for the cover-closing cylinder and for pulling back the ram of the compression cylinder is furnished at 1,500 pounds per square inch from an accumulator, served by a separate small pump, and loaded with about 15 tons of pig iron.

In service the action is as follows: About 250 pounds of material are shoveled into the box and the valve *A* is moved. This admits accumulator pressure to the cover cylinder, forces its ram outward, and closes the cover through the rack and pinion. One movement of the valve *B* then puts pump service simultaneously upon both closing and compressing cylinders. This first sends the ram of the closing cylinder forward until at the limit of travel it locks the box cover into closed position. Then as pump



THE WATSON-STILLMAN PRESS FOR BALING SCRAP METAL

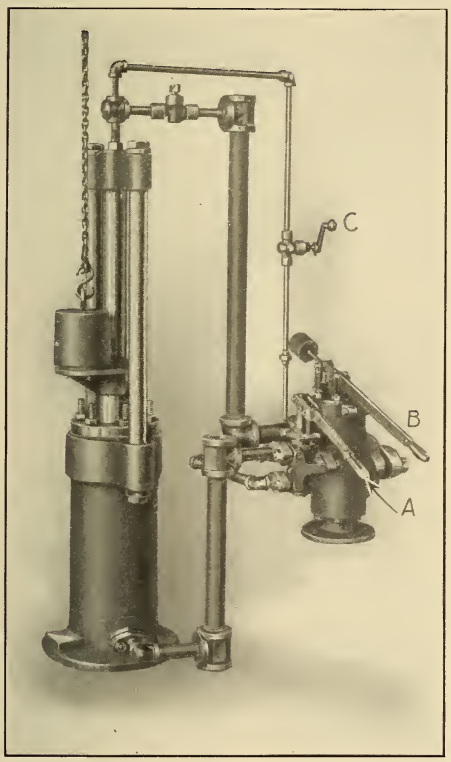
pressure in the outer end of the compressing cylinder goes above and overcomes the accumulator pressure in the pull-back end of the cylinder, the compressing ram moves forward until the pump pressure reaches the maximum of 4,900 pounds per square inch. The parts are so proportioned that this gives a total finishing pressure of 200 tons upon the bale, which reduces its dimensions to about 20 inches by 10 inches by 10 inches and makes it so compact that no straps are required.

A second movement of the valve *B* releases the forward pressure in the closing cylinder, thus permitting the compressing cylinder ram to continue pushing the bale to the left and out of the press and at the same time returning the closing cylinder ram to initial position. A third and final movement of the valve *B* then releases the forward pressure on the compressing cylinder ram, the bale drops down into the delivery chute, and the accumulator pressure, which has been constantly acting on the return end of the compressing cylinder ram, brings this ram back to initial position.

Protection from harmful overpressure is provided in the safety governor (shown at the left in the second illustration), which shuts off the pump at the limiting pressure. This governor has two cylinders, with pistons of different diameters, the larger at the bottom and in direct contact with the accumulator pressure, 1,500 pounds per square inch. The smaller is direct connected to the discharge pipe of the large automatic variable pump. The accumulator pressure being constant on the larger piston, the shelf supporting the weight is normally in its highest position. With the weight here, the pump discharges through the large operating valve either to the press cylinders or back to the reservoir. When the valve is set for admission to the press cylinders, pressure in the top part of the governor is gradually increased. As the bale compresses, the low-pressure plungers are first thrown out automatically, after which the two high-pressure pistons continue the work until the maximum pressure of 4,900 pounds per square inch is reached. When this happens, the 4,900 pounds pressure, also acting in the top or small cylinder of the governor, overcomes the pressure in the other end, forces the piston with the shelf downward, releases the weight, and causes the high-pressure plungers of the pumps to be by-passed. By opening the small valve *C* shown in the vertical pipe line, the pump is started again.

Where desirable to deliver the finished bale onto the operating floor, a three-cylinder construction is neces-

sary, the extra cylinder being placed vertically under the bale and the upper end forming the bottom of the baling box. The dimensions and operating system of such a system can, of course, be varied to comply with any service conditions.



OPERATING SYSTEM, WATSON-STILLMAN PRESS FOR BALING METAL SCRAP

This press shows another example of the present tendency to increase the efficiency of operation, decrease labour cost, and effect saving of both material and labour wherever possible, objects which wise management always keeps well in sight.

Saginaw Has the Smallest Rope Drive in Michigan

This magazine has published from time to time some very interesting stories of big rope drives installed by the Dodge Manufacturing Company in various sections of the country, but it has remained for Witter's Laundry, of Saginaw, Mich., to provide material for the smallest drive, at least in the Wolverine State.

The drive placed by the Dodge engineers in the early part of 1910 is made up of 1-inch blue strand rope in five wraps, and is to-day furnishing 70 horse-power to turn the wheels in the Witter plant. The sheave on the engine is 72 inches in diameter, capable of 150 revolutions per minute, while the sheave on the line shaft is 54 inches. The rope travels 2,828 feet per minute.

The line shaft is 8¼ inches higher than the engine shaft, with 17 feet between centres. The tension carriage is 42-inch style "O," with 15-inch track gauge, and 11 feet, 3 x 3 angle-iron track, taking up all the space available. The loose winder (54 inches in diameter) runs beside the driven sheave on the shaft. The centre of the drive is 9¼ inches from the brick wall, as shown in the accompanying illustrations. Three hundred and twenty-five feet of rope was used for the job.

In connection with the article in this issue entitled "Is Electric Traction Coming for Main Line Railways?" the following statement of President E. P. Ripley, of the Santa Fé Railroad, is of much interest:

"Within twenty-five years electricity will have entirely supplanted steam locomotion on all the railroads of the country. Already," he says, "electricity has been applied to the suburban traffic on many of the Eastern lines, and the electrically-operated system is rapidly growing. It seems probable that a few years will see electricity used as the motive power of all trains, freight as well as passenger, and trans-continental as well as local."

Both sides of this important questions are discussed by authorities in the article appearing elsewhere in this issue.

NEW PLANT OF AMERICAN INFUSION STEEL PROCESS COMPANY. BUILDING NO. 19 BUSH TERMINAL, BROOKLYN, N. Y.

OPENING OF NEW PLANT OF THE AMERICAN INFUSION STEEL PROCESS COMPANY

ON February 7 last, the American Infusion Steel Process Company entertained a number of prominent engineers and manufacturers at their new plant in Building Number 19, at the Bush Terminal, Brooklyn, New York.

After an inspection of the plant, the workings of which were explained by Mr. Alfred J. Thompson, vice-president and general manager of the company, the officials and their guests sat down to an elaborate and most enjoyable luncheon served in one of the large rooms of the new plant. As place-cards, each guest found at his plate a knife made from an iron spike, the blade of which had been made into steel by the infusion process, and bore his name.

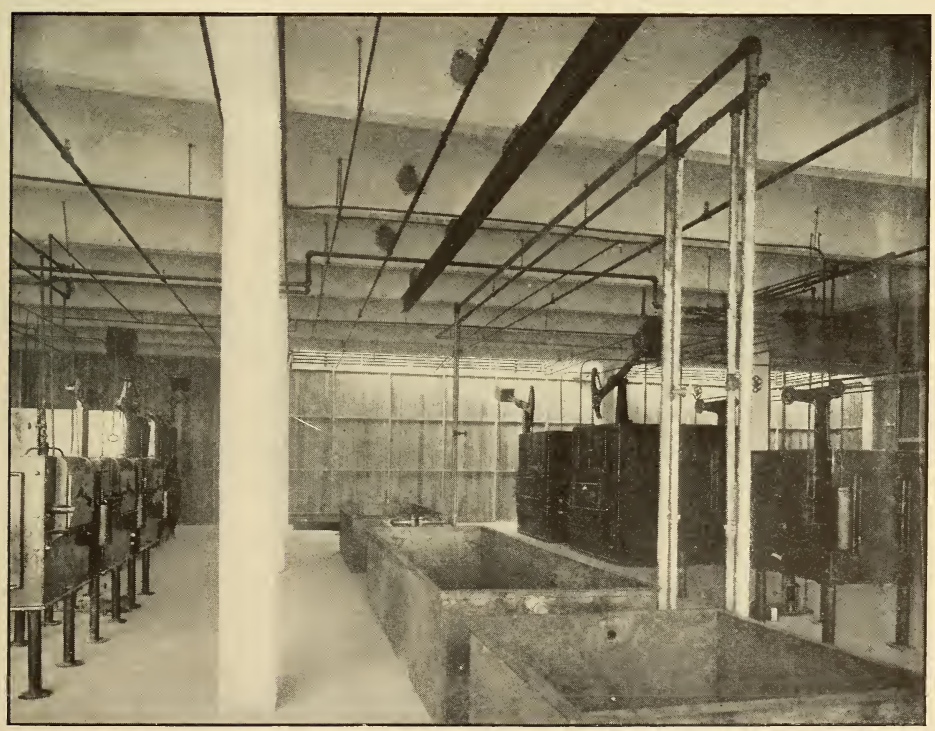
The manufacturing plant where "Stelpro" is produced is equipped with grinding mills and crushers manufactured by the Abbe Engineering Company, burr stone mills made by Charles Ross & Son Company, automatic weighing apparatus from the Richardson Scale Company. The elevators for transferring the material through the several stages of manufacture are the product of H. W. Caldwell & Son Company. Bins and elevators are of steel, and all apparatus is driven by electricity, the entire operation being as nearly automatic as it is possible for modern engineering skill to make it.

The treating plant is equipped with fuel oil furnaces varying from 48 inches to 18 inches, made by the Rockwell Furnace Company, and a very complete pyrometer outfit, from the Hoskins Manufacturing Company, has been installed. Quenching tanks, oil tanks with cooling apparatus, overhead tramways and especially

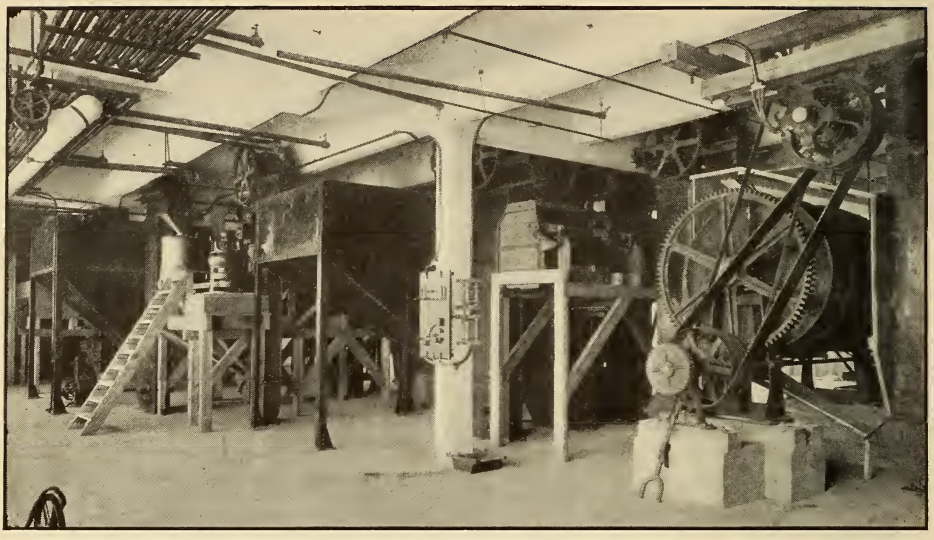
AMERICAN INFUSION STEEL PROCESS CO. PLANT

OFFICIALS AND GUESTS OF AMERICAN INFUSION STEEL PROCESS COMPANY AT LUNCHEON

Head of Table.—A. E. Stillwell, president.
Standing Against Wall.—One, A. C. Dodge, director; two, Alfred J. Thompson, vice-president and general manager; three, William N. Thompson, secretary; five, A. Colliva, technical director; six, P. D. Johnston, chief engineer.



TREATING PLANT, AMERICAN INFUSION STEEL PROCESS COMPANY



PLANT FOR MANUFACTURING "STELPRO." AMERICAN INFUSION STEEL PROCESS COMPANY

designed trucks and other necessary apparatus are all of the most approved design, and in every respect this plant is of the highest order of up-to-date modern engineering practice.

This new process of converting low-grade metal into high-grade steel is meeting with great success, and was fully described in Mr. Thompson's article on "Infusion Steel Processes" in the January number of this magazine. The process is an ideal one for producing upon articles made of iron or low-cost soft steel such portions of special steel as may be desired at will, and possesses great possibilities for the economical production of many manufactured products too numerous to mention.

AN EFFICIENT, ECONOMICAL STEAM TURBINE

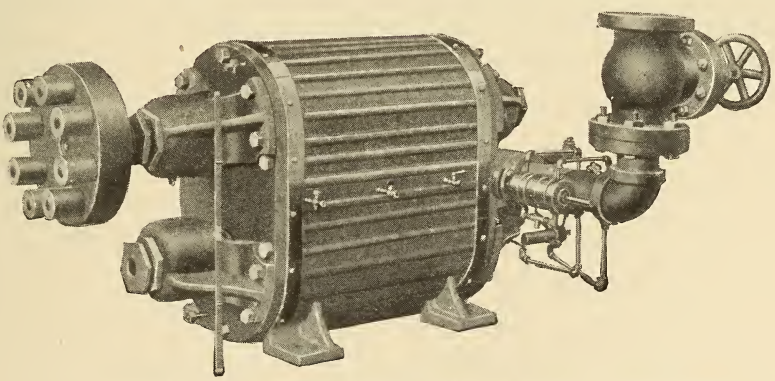
By O. D. Lee

THERE has recently been put on the market in the United States, Canada and foreign countries a strikingly new type of combined impulse and reaction turbine, which fills a gap which has long been the goal of manufacturers of existing steam turbines, it being of small size and ranging in horsepower from the smallest up to several hundred.

This turbine, which is called the "Spiro," is the invention of Mr. John H. Van Deventure, superintendent of the Buffalo Forge Company, of Buffalo, N. Y., and those closely connected with this company have for several years been anticipating the successful termination of the experiments and tests which have been known to be conducted at their plant with a view to crystallizing into a practical, matter-of-fact machine the ideas which formed the nucleus of the invention.

The salient points, strength, durability and economy of the "Spiro" are assured by three years of development and perfection which already lie behind it, and it is pronounced by many eminent engineers to be an important step forward in the art of steam engineering, as any turbine invention necessarily must be termed which brings about a steam economy ranging from 20 to 50 per cent. better than the best of existing standards, which is what is claimed for the "Spiro."

The construction of the turbine is extremely simple. It consists essentially of five parts—the case, two heads with bearings, and two rotors. These rotors consist simply of helical gears, cut by special machinery, without any loose or inserted blades. The steam action within the pockets formed by these spiral gear teeth is theoretically perfect, making full use of the impact of the fluid, due to its velocity, and avoiding the leakage usually found in turbines, which is the chief cause of their lack of mechanical efficiency.



185-HORSE-POWER "SPIRO" TURBINE MANUFACTURED FOR BUFFALO FORGE COMPANY

The first impression of the "Spiro" is its extremely small size for a given power. The illustration showing the

(Continued on page 84.)

Industrial Electric Traction

ONE of the great transportation questions of the day appears in the comparative studies which are being made as to the relative advantages of the steam and the electric locomotive, or rather of steam and electric traction for general railway service. Advocates of both sides are numerous, and strong arguments in favour of either type of transport are not lacking.

It is natural that any such sweeping change as the conversion of great railway transportation systems from one kind of motive power to another should demand most critical technical and practical study, and it will probably be found that the commercial questions involved may prove to be the controlling ones, at least in the early stages of the subject. When, however, there has been but little done in power traction of any kind; when the slate is clean, so to speak, the question of motive power is one which will naturally settle industrial establishments, at least so far as the matter of internal transport is concerned. Many manufacturing concerns have already installed industrial railways, both within building and throughout yards and outlying portions. In some instances the demands of the service are fully met by the use of manual power, while in other cases the electric storage-battery locomotive has been introduced to haul such combinations of cars as may be demanded. In nearly all cases, however, electric power has been used, both on account of the undesirability of introducing the steam locomotive into the shop and because the general employment of electric driving of other machinery renders a supply of current available.

For some purposes it has been found desirable to use the overhead trolley wire for the supply of current to the cars in which material is transported in an industrial establishment, and when the general arrangement of the equipment is suited to this method a very effective and efficient method of handling all kinds of material becomes available.

In order that such a system of transport may be employed to its full advantage, it is essential that the equipment be designed for the service under consideration. Thus, if material is to be handled in bulk, the employment of self-dumping trolley cars provides both the power for transport and the mechanism for unloading, so that one man may readily handle fifty to one hundred tons of material per hour over distances as great as five hundred feet, according to local conditions and requirements.

When such methods are compared with former ideas as to the value to be obtained from the services of a workman, it must be realized that the true way to secure high efficiency is to provide power apparatus to do the heavy work, reserving for the man the control and direction of the power and the mechanism, and relieving him of the necessity for exerting his muscular strength, except within very small limits.

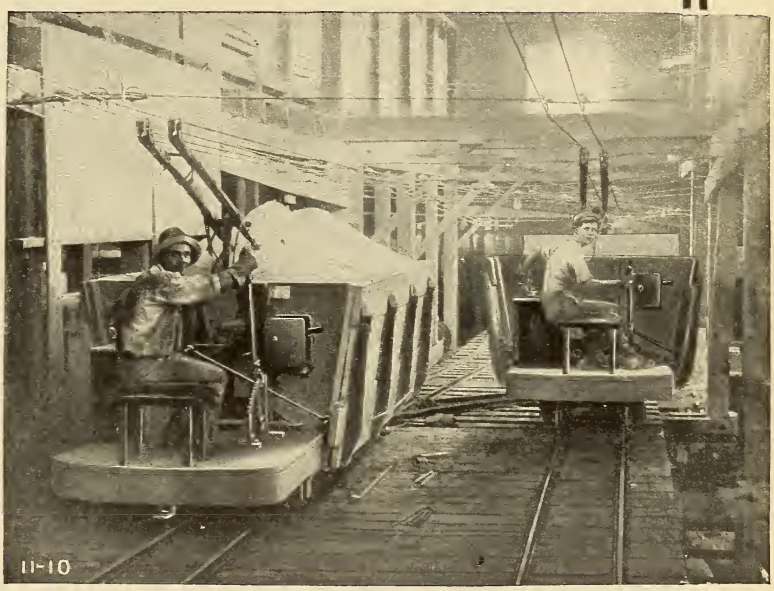
When the operative cost of such an equipment is taken, together with a fair allowance for depreciation and repairs, and comparison is made with older methods of handling an equivalent amount of material, it will be seen that such appliances form the greatest aids to the attainment of efficiency at present available. The surest way to appreciate the value and service of such an equipment is to be deprived, for any reason, of its services temporarily, and to be compelled to handle the material by earlier and less scientific methods. Any such compulsory return, even for a brief period, to methods of handling which were formerly considered altogether practical, is sure to create an urgent demand for the modern power operated system, with a feeling of wonder as to how the older ways could ever have been tolerated.

HUNT

Self-Dumping TROLLEY CARS

for handling Materials in Bulk

THESE CARS, while operating under existing unfavorable conditions which do not permit their working at highest efficiency, are each handling, with one man, fifty tons per hour, a distance approximately of five hundred feet, and this capacity is easily doubled when the cars are used under less severe conditions. The track over which they are run includes several 7 per cent. gradients and 12-foot radius curves. Power is obtained from an overhead trolley wire, and the car is fitted with hand brakes and controller.



"Hunt" Self-Dumping Trolley Cars Handling Fertilizer Materials from Vessels to Storage.
Miller Fertilizer Company, Baltimore, Md.

These cars are made of different sizes and types to meet varying conditions.

We design and install complete equipments for handling fertilizing materials from water front to storage. Write us to-day for Bulletin No. E.1, and for further information, or apply to our nearest branch office.

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Trying Things Out

THE veteran engineer, Mr. John Fritz, tells how, in his experience in the construction of various kinds of mechanical equipment, he would inquire if the apparatus under consideration had been made according to design, examined by the men responsible for its details, and checked by the plans and drawings, and if the replies to these questions were satisfactory, he would say: "Well, then, start up, and let's see why it won't work!"

Like every experienced engineer, he realized that there might be some unforeseen difficulty, lying in wait to appear and make trouble and require attention before smooth operation could be secured.

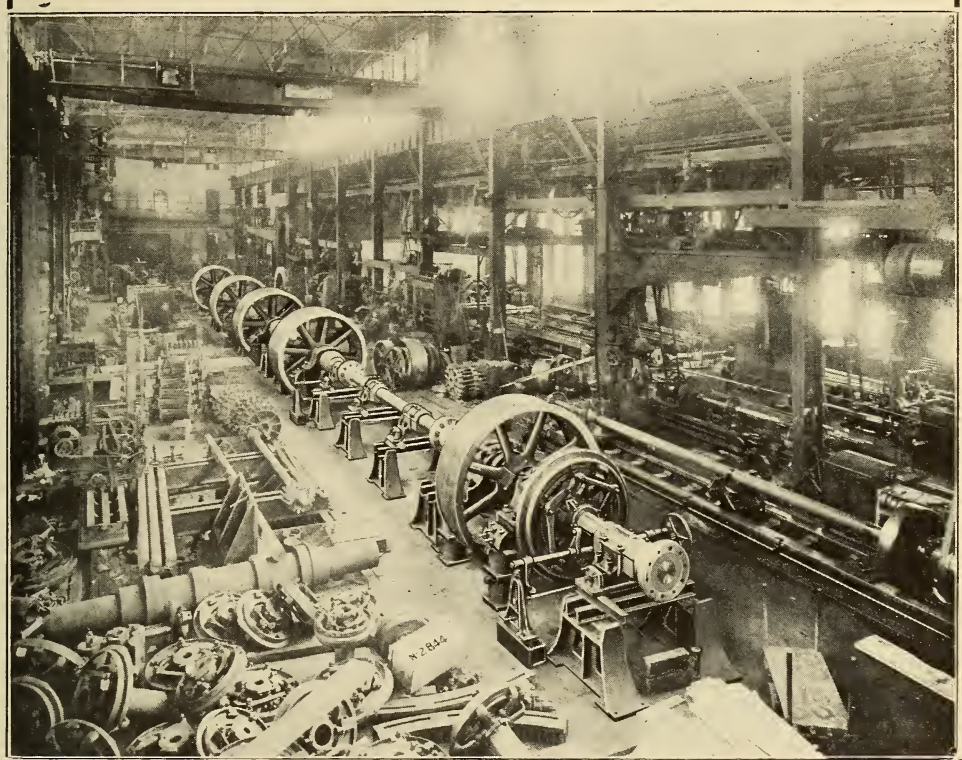
However skillful the designer and however careful the workmen, such troubles are almost inevitable. The plans of any construction may be prepared with all foreseen difficulties in mind; but the unexpected will happen, and no foresight can be expected to include everything.

Such being the case, the careful engineer perceives a method of handling this element in the problem, one which anticipates the possibility of a hitch, and remedies the delays and troubles which might otherwise occur. This plan is simply to erect and test the equipment in the works of the manufacturer, and thus ascertain and correct any difficulties before delivery and final erection in the establishment of the purchaser. In some kinds of work such a plan is impracticable, but in the great majority of cases it is altogether possible to put the parts together, and subject the work to an operative trial under conditions which remove all uncertainty.

There are numerous advantages in this method of procedure, apart from the obvious satisfaction which it gives to the manufacturer himself to be assured that his product is wholly complete. In many instances the location in which the apparatus must be placed when in actual service may be such as to render close inspection and test inconvenient, and any modification or adjustment, apart from that included in the design, may be made much more readily and accurately on the testing floor than in the customer's establishment. In any case the detection and location of any disturbance or impediment to smooth operation is much easier when the whole equipment is erected and tried out under the keen eyes of the trained inspector than after the parts have been delivered and erected in some distant establishment. If an equipment has been once put together, tested, tried out under power and load, and critically inspected, the assurance of satisfactory operation in place is secured beyond question.

In addition to the removal of the possibility of troubles by following this process of shop erection and test, the method offers especial advantages in the effort to obtain maximum efficiency in operation. It is not sufficient that an equipment, such as a system of power transmission by shafting, belting, pulleys, clutches, etc., should merely work, and transmit and distribute power as desired. It should do this with a minimum of waste energy, which means a maximum degree of efficiency. Since the ultimate efficiency of any sequence of operations is obtained by multiplying the efficiencies of the successive elements, it is most desirable that an element of low efficiency should not enter into combination with others of higher value, and thus pull down the efficiency of the whole. When, however, the parts of a system are not erected and tested together before delivery, it is not always possible to determine the location of the elements of lesser efficiency, and thus an equipment which, to all appearances, may be working well enough in position, may be far less efficient than if it had been inspected, tested, and tried out in the shop of manufacture.

DODGE



Scene in One of the Dodge Machine Shops at Mishawaka, with Machinery Under Test.

Actual Working Test of Every Transmission Outfit

NO complete mill outfit of power transmission machinery ever leaves the Dodge plant until it has been thoroughly tested and proved perfect.

Under the direction of master workmen and engineering experts each job is set up, fitted and run, just as in actual service. The try out, under the eyes of these men, is even more severe than ever could be encountered in usage.

This is one of the fundamentals of Dodge service—a basic principle of the Dodge Idea.

No manufacturer ever needs to correct or refit transmission machinery bearing the Dodge trade-mark after he receives it.

Every piece of machinery is put together with perfect ease—without annoying delays—for a careful and accurate system of shop standards, gauges, tools and methods insures a mechanically perfect assemblage of correctly fitted parts.

Yet, not trusting to standards alone, we set up the equipment in our shops at Mishawaka, and give it a real test before delivery to the customer.

Machinery of Dodge design and make when erected starts without hitch, taking up its regular load at once, continuing through service without stopping, and giving satisfaction entire as time goes on.

The Dodge line should be your shop standard, because it embraces everything for the mechanical transmission of power—the split feature and interchangeability wherever possible—wonderful reduction of friction in transmission, saving many dollars of power waste, and the immense economy of self-oiling bearings and friction clutches to control departments independently.

We publish a national magazine, The Dodge Idea, 24 pages and cover, beautifully illustrated and printed, containing many things of industrial interest. This is free for the asking by managers, superintendents, master mechanics, chief engineers and purchasing agents of power-using plants.

Dodge Manufacturing Company, Mishawaka, Ind.

Branches and Warehouses Carrying Complete Stocks of Dodge Transmission Goods:

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Fashions in Tools

THERE is a tyranny of fashion to which we are all subject, in the texture, the cut and color of our garments, and, except for the changes which are made in recognition of the temperature conditions of the successive seasons, there would seem to be little more than an initiative caprice and then the imitative habit to account for them. There are changes of fashion also in our tools, in our ways and means of doing work, and for these it is to be hoped that more satisfactory explanations may be found.

For one thing, it is to be expected that the changes of fashion in our tools shall lead to better work or more easy and prolific accomplishment, and this expectation we are seeing constantly realized. Perhaps one of the most pronounced changes of fashion in our tools is occurring, or has occurred, we may say, within the century which is still young, and in one of the most strenuous and exacting of our industries. We have to recognize the fact that in certain lines of rock drilling the hammer drill is becoming the fashion, and the percussion drill is no longer sure of universal employment. This changing fashion is not born of caprice nor extended by servile imitation, but is dictated by judgment and experience and endorsed by practical results.

The change of fashion from the percussion drill to the hammer drill is, as often happens with all our fashions, not the exploiting of a novelty, but a reversion to the fashion which prevailed long ago. The hammer drill works upon the same principle as the hand drill, while the reciprocating bit-carrying piston was a distinct and radical departure in mode of operation from the hand-held, sledge-driven drill which it displaced and in results accomplished so greatly excelled. It would seem now that the persistent success of the reciprocating drill is to be attributed to other features and accompaniments rather than to the reciprocating principle in itself.

Indeed, it is not easy to understand why the inventors of the first power rock drills did not imitate the hand drill operation. The hammer drill does. The bit is pressed tightly and constantly against the rock, and the hammer blows are showered upon it with a sharpness and rapidity little to be compared with the thud, thud of the heavy piston-carried bit. No matter how deep may be the hole, within the working limits of the drill, or how much the hole may be choked by the accumulation of mud, the stroke of the hammer is just as sharp and quick at all times, which is very different from the action and effect of the reciprocating bit.

The discarding of cumbrous appurtenances, the lightness of the hammer drill itself and the means of placing it and holding it to its work, as compared with its predecessor, give it, perhaps, its greatest advantage.

It is, in the first place, a one-man instead of a two-man or a three-man drill. It dispenses with the tripod and the heavy weights to hold it down, and it has as little use for the column or bar with their jack screws, to be so carefully set up and so constantly watched. The drill is just lifted to the required position and then a puff of air not only holds it securely, but also does the feeding when in operation. The drill, therefore, like the express train, makes much of its gains by shortening its stops and keeping continually at it.

We must keep up with the fashions in dress or life is not worth living, and in the competitions of business following the tool fashions is still more imperative, for without them progress ceases and success departs. The fashions in either line rarely originate with those who follow or adopt them. Those who originate the tool fashions have great responsibilities, and they only hold their own by keeping always in the lead.

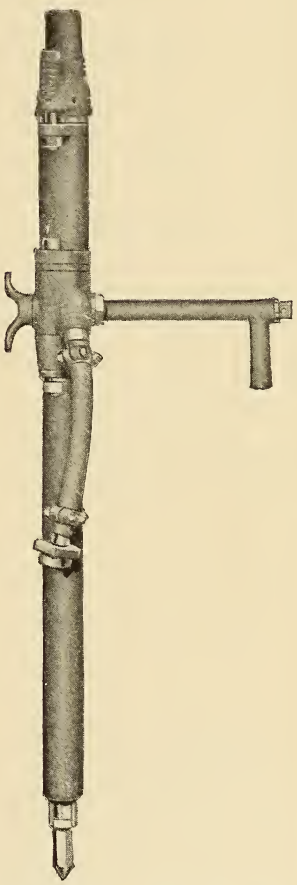
Hammer and Stoping Drills Depend For Their Success Upon The Drill Knowledge Their Builder Has

The first hammer drills were modified pneumatic tools. And it didn't take long to find out that you cannot drill rock with a pneumatic hammer.

Then we took hold of the problem—and set out to build hammer, plug and stoping drills that were **specially designed for drilling rock.**

We had the greatest drill building and rock drilling experience in the world to guide us—and that experience manifests itself in the present types of Ingersoll-Rand Hammer and Stoping Drills, which have the characteristic small drill advantages combined with the best rock drill features.

Here again is where you buy **service** as well as **drills,** in buying Ingersoll-Rand types. For they are the fruit of the most complete manufacturing facilities in rock drilling machinery in the world.



"Butterfly" Stoping Drill: This Type, as well as the "Imperial" Valveless Drill, can be had in Hand and Plug Drills.

NEW YORK **INGERSOLL-RAND CO.** LONDON

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COMPRESSORS ROCK DRILLS COAL CUTTERS PNEUMATIC TOOLS

The Mechanical Shovel

ONE of the notable developments in modern methods of manufacturing power appears in the concentration of the operation into great power plants, generating thousands of horse-power, and distributing it over large areas, either within manufacturing plants or over industrial districts. Such a method has naturally brought with it corresponding modifications in the apparatus by which the power is generated, and these modifications have created demands for special apparatus.

The ordinary boiler room of the modest manufacturing establishment was not too large to be tended by manual labor; and although it was evident that even on such a small scale the efficiency was none of the best, the total cost of handling the fuel and ash was not great enough to offer any very attractive opportunity for improvement. With the growth of the great power plant, however, the conditions have been changed, and the efficiency of the entire plant is found to depend very largely upon the manner in which the coal, the material out of which the power is made, is received, handled, and, so far as its non-combustible portion is concerned, is cleared away.

When the man did work by muscular effort, he used what is probably one of the earliest and simplest tools known, and the shovelling of coal or ashes, while involving a certain degree of experience and facility, was classed as a rather low order of labor.

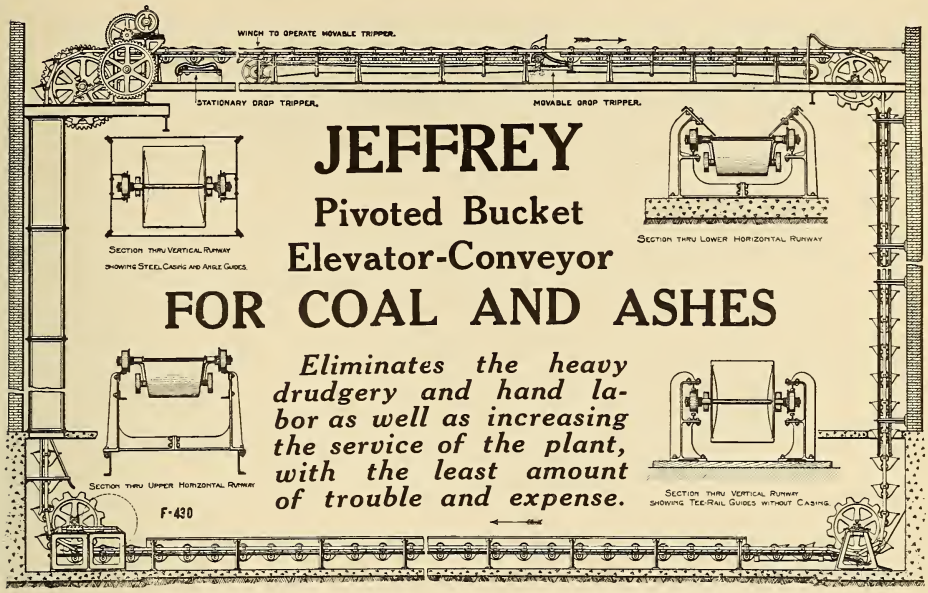
In the stationary power plant, however, the mechanical shovel, operated by the power which it helps to manufacture, is replacing the hand tool to an extent which forms one of the most interesting examples of the replacement of the man by the machine.

It is interesting to note that in most cases when a mechanical device is employed to replace animal action the construction and movements which appear in Nature are not precisely reproduced; the steamboat does not imitate the fish or swimming bird, the wheeled vehicle is dissimilar from the legs of man or beast, and the aeroplane is not a copy of bird or insect.

In like manner the mechanical shovel is different from the hand tool both in its construction and in its operation. There are no arms, holding and moving a scoop shovel in intermittent fashion, but instead a continuous series of buckets, carefully designed to contain predetermined quantities of fuel, and so arranged as to receive, transport, and deliver the coal from the arrival at the plant to the discharge of the ashes.

It has been said that the ideal fuel for power generation is that which is originally in the liquid form, so that it may be piped from a tank to the point of combustion; but with modern coal and ash-handling machinery the mobility of liquid fuel is practically secured, while the advantages of solid fuel are retained. The elevation and delivery of coal to storage bins is similar to the storage of a liquid in a reservoir, while its conveyance and delivery to feeding chutes forms a close analogy to the piping of a liquid, using the force of gravity and controlling the flow by gates and valves. In both cases the part of the attendant is limited to control and direction.

The principles which have thus been developed for the elimination of the manual shovel and the introduction of the mechanical shovel are not limited to the handling of coal and ashes; but just as the old fashioned shovel found its work in moving earth, ore, sand, gravel, and similar granular material, so the continuous mechanical shovel is being applied everywhere to the handling of material in bulk, to the relief of heavy drudgery and the increase in efficiency of the operation.


WINCH TO OPERATE MOVABLE TRIPPER.
STATIONARY DROP TRIPPER.
MOVABLE DROP TRIPPER.
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SECTION THRU LOWER HORIZONTAL RUNWAY
SECTION THRU UPPER HORIZONTAL RUNWAY
SECTION THRU VERTICAL RUNWAY SHOWING TEE-RAIL GUIDES WITHOUT CASING
F-430

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Pivoted Bucket Elevator-Conveyor

FOR COAL AND ASHES

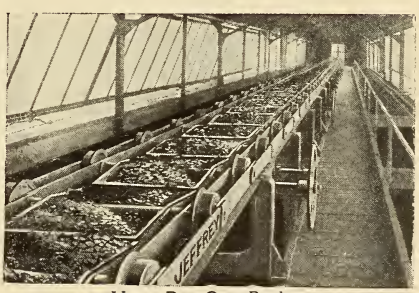
Eliminates the heavy drudgery and hand labor as well as increasing the service of the plant, with the least amount of trouble and expense.

THE buckets receive the coal from receiving hopper and discharge same to storage bins by means of movable Drop Tripper. The Coal is fed through chutes to the stokers.

Ashes are dumped into conveyor and delivered from ash pits directly into lower horizontal runway of conveyor and carried to ash bin usually located under Stationary Drop Tripper.

Our Pivot Bucket Conveyor systems are built in several sizes with capacities ranging from 25 to 100 tons, and are also adapted for handling hot clinker, ore, and other bulk materials.

Jeffrey Coal and Ashes Handling Equipments are designed and built to meet every practical requirement.



Upper Run Over Bunkers.

Catalog No. 32 describes over fifty different installations. Free to any Engineer who will call on, or write to, any of our offices or agents.

We have recently issued a New Power Transmission Catalog No. 50, which is just off the press. Yours for the asking.

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Square Deal Figures

THE latest addition to the many features peculiar to FINANCIAL AMERICA is the table showing actual values of the common stocks of the railroads which go to make up the bulk of the trading on the stock exchanges of the country.

These figures are ascertained after careful analysis of the reports of the several companies. They serve as a monitor to the investor inasmuch as they show actual values as they now exist, irrespective of stock market prices.

It is well understood that stock market prices include possibilities of future development, and other factors which go to make up speculative values. FINANCIAL AMERICA'S figures are based entirely upon current earnings, the reader being permitted to exercise his own judgment as to what the future may contain.

The reader must be his own judge as to whether the stock market prices are too high or too low. FINANCIAL AMERICA in this table supplies a basis for such mental operation, which, until now, has not been at the ready disposal of the general public.

This new feature in FINANCIAL AMERICA, properly studied, will, it is believed, prove of great usefulness to the investor. The compilation is, in fact, a condensed analysis of all the great properties mentioned, and thus becomes of additional value inasmuch as "a line" is furnished upon senior issues as well as upon the common stocks.

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FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

OF THE
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SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor

CHARLES EASTON, Financial Editor.

The Situation

THE information gathered by this magazine from dependable sources during the past month justifies a favourable conclusion as to trade conditions and also indicates that the sense of fear with which the average business man seems possessed is the very root of most, if not all, the ills that beset the commercial world.

As we view it, the principal obstacle in the way of business advancement is failure to overcome this feeling of timidity on the part of consumers, which is fostered to some extent by the political uncertainties of a Presidential year, and has resulted in the adoption of a hand-to-mouth policy in purchasing goods of all descriptions.

We hear disappointment expressed in some quarters because business conditions have not improved more rapidly. In our judgment, one of the most encouraging features in the present situation is the fact that business has gone forward in spite of a decided disposition on the part of men of affairs to make haste slowly. The volume of business generally is good, and in some quarters notably large, and, while the percentage of profit has been somewhat reduced, it is, nevertheless, convincing evidence that conditions are not as bad as a few pessimists and impractical reformers would have us believe.

The outlook for the iron and steel industry is considered favourable. The situation in the dry goods, woolen and leather markets is encouraging. In the main, the prices of commodities have held firm. The January earnings of railroads were about the same as last year. The investment markets have improved, while the speculative side of the financial world is decidedly sluggish.

It must be acknowledged that a few clouds hover over the business horizon, but they are not of a threatening character. The occasional talk we hear of a panic and business reversal is entirely nonsensical, and is characteristic of those who persistently find fault with things as they are without offering a single suggestion that would tend to make matters permanently better.

Interest continues to centre in the government's action against corporations, and the sentiment in favour of a sane application of the "Sherman law" to corporate institutions is gaining ground. If the dissolving of these overgrown combinations into a multitude of minor parts insured com-

petition that would better safeguard the interests of the people against the unfair, greedy and oppressive methods too frequently employed by large business organizations, the law should be drastically enforced.

However, inasmuch as it is generally admitted that you can no more legislate competition into commerce than you can legislate morals into men, we are unable to see what real good is to accrue to the public from a purely physical dismemberment of these great corporate bodies. Before any good can be accomplished it is evident that we must first control the individuals responsible for the business policy and management of such combinations to whose unworthy motives and selfish desires is chargeable all the evils resulting therefrom, and we believe this can best be done by rational supervision rather than reckless sub-division on the part of the government.

Question—Would you advise the purchase of Allis-Chalmers bonds?

Answer—We regard the bonds of the Allis-Chalmers Company as a reasonably good "buy" at prevailing prices.

Judging from recent reports of some of the large textile machinery companies, business in this particular line has been unusually prosperous. It would seem that many old-time New England mills have been spending large sums of money putting their "house in order," by replacing old machinery with new.

The year 1912 bids fair to be an exceptionally good year for the manufacturers of typewriters. It is interesting to know that typewriters are made for every language in the world, with the exception of Chinese, and experiments are now being made with the view of making the typewriter practical for the Chinese language.

In the heart of the New Business Centre of the U.S.

Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

The Chelsea Exchange Bank

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NEW YORK

Safe Deposit Vaults. Boxes $5.00 per year up

A Continually Growing Bank in a Continually Growing District

There is a decidedly optimistic view regarding coppers, both metal and the stocks. The metal has been strong at 14½ cents, and many well-informed people think we are facing a broad and active market in the better copper shares. Large exporters of the metal prophesy another heavy decrease in the supply for the current month.

The Western Union and Postal Telegraph Companies have apparently started an interesting fight before the Commerce Commission. It is attracting particular attention at this time, because of the Postmaster-General's recent suggestion that the government take over the telegraph and telephone lines. The difference between these two great companies in wire mileage and the number of offices is remarkable. The Postal touches only the high places, as it were, with about 3,000 stations and only 300,000 miles of wire. The stations are located in the districts most densely populated, which produce 80 per cent. of the country's telegraph business. The Western Union Company have 1,500,000 miles of wire and 25,000 offices, which practically cover the entire country.

Question—Can money be invested safely to net more than four per cent.?

Answer—In our judgment, it is possible under existing conditions to invest your money to net considerably more than four per cent., without taking the slightest chance on the safety of your principal. We will be glad to give further particulars on request.

It is stated on good authority that the $25,000,000 loan which the Canadian Government now has ready to float is being received with a little hesitancy in London. Canada has borrowed tremendous sums in Europe. While it is not suggested that the Canadian situation in unsound, yet it is apparent that conservative minds regard the growth as being slightly too rapid for safety.

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The consolidation of the Bankers Trust Company with the Manhattan Trust has been approved by the State Banking Department. The combined institutions will have deposits of about $160,000,000. It is classed as a Morgan institution. Latest official reports show that Morgan banks are now carrying a little over $900,000,000 of deposits. The interest in the merger is intensified at this time because of the recent Congressional proposal to investigate the so-called Money Trusts.

Question What do you think of the 'Frisco refunding 4s?

Answer—The four per cent. bonds of the St. Louis & San Francisco Railroad system we regard as a good investment. The bonds are amply secured and the road is improving its financial condition, and its earnings are showing up well. The 'Frisco system passes through the best farming section of the great Southwest, and its prospects for increased business are excellent, especially from the Rio Grande Valley and Gulf Coast sections of Texas, because of rapid developments in these localities.

The imports of general merchandise of the port of New York for the week ended February 17 were as follows: General merchandise, $16,491,823; in the same week of 1911 they were $14,385,839.

The Baldwin Locomotive Works have just issued their statement covering the half year ended December 31, 1911. The report shows that net earnings amounted to $3,243,409, an increase over 1910 of $726,810. The board of directors of the company authorized the purchase of 378 acres of land at East Chicago, Ind., for the purpose of establishing a Western plant.

The outlook in the steel trade continues good. The Carnegie Steel Company is operating 91 per cent. of its blast furnace capacity, with its sheet and semi-finishing mills working in full.

The report of the Baltimore & Ohio Railroad for January was most gratifying. It shows a splendid increase in business and a substantial saving in running expenses.

It is stated by the Debenture Corporation of New York in its latest "Real Estate Market Letter" that the Interborough Rapid Transit Company recently sold in one day, on the Subway and Elevated lines in New York City, 2,460,000 tickets. We may add that this is only one of many interesting items contained in this letter.

Charging that the Water-Power Trust is exerting its enormous interest to pass the Hydro-Electric bill introduced into the House of Representatives, granting certain rights in the Mono California National Forest, Gifford Pinchot, through the National Conservation Association, has issued an urgent appeal to Congress to defeat the measure. If the bill should pass, Mr Pinchot states, it would set a dangerous precedent for giving away public property to the water-power interests forever for nothing.

The United Shoe Machinery Company, under indictment for maintaining a conspiracy in restraint of trade, in its defense relies largely upon the patent law, asserting that the government has given them the right, through each separate and distinct patent, to combine and monopolize trade and commerce in the several groups of shoe machinery.

The cost of the mill strike at Lawrence, Mass., during the month that it has continued is estimated at $1,000,000. This included loss of wages to workmen and expense in maintaining the militia.

What Canada lost through the rejection of reciprocity with the United States is to be the subject of investigation by a committee of the Canada Senate.

Pine Orchard, Connecticut

is situated directly on Long Island Sound, 84 miles from New York City and 12 miles from New Haven.

This attractive resort, where you would like to live this summer, offers nearly all that any one could desire in the way of out-door sports and amusements, with its fishing, bathing and boating, also country club with lawn tennis courts, clock golf and a "sporty" golf course, splendid macadamized roads for automobiling and driving.

I live there myself during six months of the year, besides spending many pleasant week-ends during the winter. At the suggestion of some of my neighbors this advertisement is inserted for the purpose of interesting a few more congenial people, in order that desirable tenants may be found to occupy the few cottages unrented.

If a shore-front house surrounded by grass, trees, woods and country seems to appeal to you perhaps you will want to know more about these roomy houses. Everything that makes housekeeping easy in the way of city water, gas, electric lights, telephones, baths and open fire places is there.

Pine Orchard is accessible—yet retired. The grocer, butcher, milkman, baker, iceman and newsboy, make daily deliveries, but the usual fuss and conventional restrictions of summer resort life are absent.

If this sounds "too good to be true" call and see or write for photographic proof and judge for yourself.

EUGENE E. ADAMS
334 Fifth Avenue
New York City

The Society for Promoting Efficiency

WE shall in the last analysis probably have to give credit to competition for the improvements which have taken place in processes and methods in all lines of human endeavour. Of late years the direction of this improvement has tended towards increased conservation of waste in time, materials and effort, and this has become known generally by the name of "efficiency." In every movement of this kind which has a concrete purpose there are those who, having a clearer vision of its principles than others, become leaders in it, while others, for various reasons, become followers.

We are now viewing this latest movement crystallize into a definite form through the establishment by its leaders and its followers of the Society for Promoting Efficiency. It has been in progress of formation for several months, and the organizing committee has recently opened headquarters in the Metropolitan building, 1 Madison avenue, New York City, with Mr. James C. Cannon, President Fourth National Bank, chairman, and Mr. H. F. J. Porter, industrial engineer, secretary.

The membership is open to people in every field of endeavour, in order that the principles of efficiency may be made known generally and become universally applied. It will, however, devote itself first to the fields of industry and business.

Already the membership, composed of the leading manufacturers, corporation attorneys, public accountants, economists, educators, publicists, specialists in sanitation, industrial hygiene, social service, is growing so rapidly as to indicate that the society will be one of the largest of the national societies. It is intended to follow the lines which these other societies have found satisfactorily meets the needs of both these resident and non-resident members. There will be a headquarters, with a library and meeting rooms. There will be a permanent exhibit of office equipment and of sanitary and safety appliances for factories, so that a business man or factory owner wishing to carry on his affairs in the most efficient manner can select from what the market affords that which will best suit his purpose.

There will be a permanent photographic exhibit of well-designed offices, shops, employees' houses and industrial towns; also, examples of the effect of bad light, air and food on the efficiency of the employee. The inefficiency of child labour, of cheap labour, of congestion, will be pictured, and, in general, there will be presented the right and wrong ways of working. There will be a research laboratory for carrying on investigations along these lines.

There will be demonstrations of motion study and time study; of different methods of performing operations, so as to acquaint the employer and employee with the principles of efficiency.

The meeting for organization will take place in the Engineering building, 29 West Thirty-ninth street, on March 18 and 19, with a dinner in the evening of the first day, and already promises have been made by the most representative men in the field of industry that they will be present to present papers or take part in discussions. An exhibit, with demonstrations of the character above outlined, will be accompaniment of the meeting.

Merchants' Association of New York to Try New Plan to Aid Merchants

Scheme Formulated by Henry R. Towne, President of the Yale & Towne Manufacturing Company

The plan suggested by Mr. Henry R. Towne, president of the Yale & Towne Manufacturing Company, who is always in the fore in matters of civic improvement, has been heartily approved by the Merchants' Association of New York, and will, without doubt, be put into effect.

It is proposed to add five bureaus to the Association, to deal with traffic, industrial development con-

ventions, foreign trade, and publicity. The Traffic Bureau will be conducted by a railroad man of experience, who will take up the matter of freight rates which discriminate against New York, and will advise individual shippers as to rates and claims. The work of the Industrial Development Bureau will be to promote transit facilities throughout the city and to attract new industries. The Convention Bureau will seek to bring conventions here, and the Foreign Trade Bureau to extend the city's export trade. The Publicity Bureau will foster the general objects of the Association.

It has been decided to increase the membership of the Association from 1,400 to 3,000, and eventually 5,000. Last week it appeared before the Interstate Commerce Commission in support of the abolition of freight-rate differentials against the city, and this week will take part in the investigation of express companies.

The Coe Brass Ansonia Branch

It has seemed to those charged with the administration of its affairs that the maintenance of the Coe Brass Manufacturing Company as a distinct and separate organization is no longer necessary or advisable, as it appears that much unnecessary detail can be avoided by conveying and transferring all its property and assets to the American Brass Company, thus making the latter an operating company, instead of a holding company, as heretofore.

The Coe Brass Manufacturing Company's mills, therefore, are now operated as a branch of the American Brass Company, and will be known as the Coe Brass Ansonia Branch of the American Brass Company. No change whatever has been made in the personnel of the management of this plant, and it will continue to handle its own correspondence, do its own billing and collecting, and the requirements of customers will be looked after in the same efficient manner by the same people, as heretofore. The active operating officers of the Coe Brass Ansonia Branch will be: Charles F. Brooker, president, and A. S. Brown, assistant manager.

Iron Ore in 1911—Estimated Production According to United States Geological Survey

Preliminary estimates of iron ore sold in 1911 were sent to the Geological Survey by twenty-six of the largest iron-mining companies in the United States at the close of the year. The combined output of these companies represents more than 80 per cent. of the total production of the United States. From these returns it is estimated by E. F. Burchard, of the Survey, that the total quantity of iron ore marketed in the United States in 1911, not including stocks left at the mines, was between 43,000,000 and 46,000,000 long tons. This quantity represents a decrease of 22 to 24 per cent. of the sales for 1910, which aggregated 56,889,734 long tons. The output for 1910 was the largest quantity of iron ore ever

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marketed in a single year in the United States, and, according to the present estimate, the quantity produced in the year 1911 will take fifth place, being exceeded by that of 1910, 1907, 1909 and 1906 in the order named. It is estimated that of the ore produced in 1911 between 39,250,000 and 42,000,000 long tons was red hematite, the remainder consisting of brown hematite, magnetite and iron carbonate ores. According to the returns received, the Lake Superior district, in Minnesota, Michigan and Wisconsin, apparently produced between 33,000,000 and 35,000,000 long tons of red and specular hematite, which represents a decrease of 23 to 28 per cent., compared with the production of 1910—46,328,743 long tons.

In the Birmingham district, Alabama, the second largest iron-mining centre, the production of iron ore apparently decreased 18 to 20 per cent. from that of 1910, the estimated production for 1911 being between 3,050,000 and 3,125,000 long tons, compared with 3,802,115 long tons in the preceding year. The ore mined in the Birmingham district consists of red and brown hematite in the proportion of about 4 to 1.

The production of iron ore in Tennessee and Virginia apparently decreased only about 16 per cent.

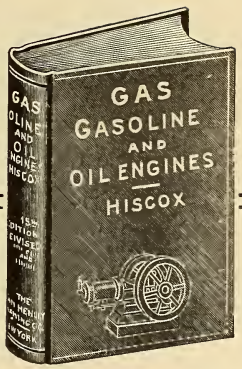
As the production of pig iron for 1911 may exceed 23,500,000, a larger production of iron ore might appear to be required than has been estimated above; but it must be considered that at the close of 1910 there was 9,408,235 long tons of iron ore in stock at the mines in the United States, and that of this total 8,471,108 long tons was at the mines in the Lake Superior district. Just how heavily this surplus stock of ore was drawn upon in 1911 it is impossible to state at present; but, owing to the increased activity in the manufacture of pig iron toward the close of 1911 it is probable that the 1910 surplus was in part cleaned up and that at the end of 1911 only a relatively small quantity of iron ore remained at the mines.

BOOK NOTES

The Resources of Tennessee, a magazine devoted to the description, conservation and development of the resources of Tennessee, is issued monthly, and contains much of interest. A sample copy may be obtained by addressing Mr. Geo. H. Ashley, State Geologist, Nashville, Tenn., and mentioning CASSIER'S MAGAZINE.

The *Electrical Journal,* P. A., Box 911, Pittsburg, Pa., has recently issued its Eight-Year Topical Index in the form of a 48-page publication, which is arranged so it can be used in bound form or mounted on cards for use in a card file. This index covers a wide range of articles of engineering interest, and covers some 6,500 pages of valuable technical material which has appeared in the *Electrical Journal.* Its arrangement is such that any and all articles are readily located, and it will be found most useful.

Announcement is made of the reorganization of The Watson-Stillman Company, manufacturers of hydraulic machinery, with a plant at Aldens, N. Y., and general offices at 50 Church street, New York, N. Y. It is stated that the increasing use of hydraulic presses and the steady growth of the business necessitate an immediate extension of the company's manufacturing facilities. To take care of business increase it was considered advisable to reorganize the board of directors. The new officers elected are: Francis H. Stillman, president (re-elected); E. A. Stillman, vice-president; J. P. Bird, treasurer; A. F. Stillman, secretary and works manager, and Carl Wigtel, chief engineer.



GAS, GASOLINE AND OIL ENGINES
By GARDNER D. HISCOX, M.E.
Just issued. Twentieth edition. The book treats on the theory of Gas, Gasoline and Oil Engines as designed and manufactured in the United States. Explosive motors, stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric Ignition by Induction Coil and Jump Sparks are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. 450 octavo pages, fully illustrated by 351 engravings. Price.....**$2.50**

MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT
By OSCAR E. PERRIGO, M.E.
A work of 400 pages, dealing with every problem connected with the building and conducting of a modern factory or shop. The subject-matter embraces the designing of the buildings, the installing of machinery, etc., and the turning out of work. For convenience the book is divided into three parts: The first part deals with the construction and the providing of power, heating and ventilating and lighting; the second part takes up the equipment, both mechanical and administrative, and the third part pertains to management, introducing a simple and efficient time and cost system.
Price.....**$5.00**

HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL
By JOSEPH V. WOODWORTH
A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price.....**$2.50**

PATTERN MAKING
By F. W. BARROWS, Practical Pattern Maker
This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price.....**$2.00**

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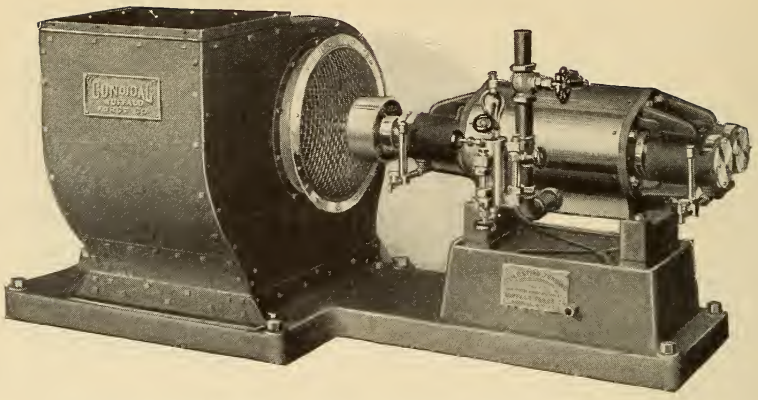


TEN-HORSE-POWER "SPIRO" TURBINE DIRECT CONNECTED TO 25-INCH FAN

An Efficient and Economical Steam Turbine

(Continued from page 65.)

185 horse-power turbine illustrates this forcibly. This particular outfit has been in use for the last three years as a motive power in driving fans, gas scrubbers and other apparatus requiring a running test. It has not been apart or had a single adjustment made upon it since its installation. The stated power of this outfit—namely, 185 horse-power—was developed under 100 pounds initial pressure. It has been decided to base the rating of all "Spiro" turbines on this pressure, in opposition to common practice among turbine manufacturers, who use 150 pounds initial pressure as a basis. This appears to be a sensible move, as 100 pounds unquestionably comes closer than 150 pounds to representing the initial pressure under which small size turbines, as a rule, are required to run. The latter rating, with corresponding water rates, has always been somewhat misleading.

The "Spiro" is at present manufactured in sizes from 1 to 50 horse-power, non-condensing; and patterns are being rapidly completed for an extension of sizes up to 300 horse-power.

It is found that in many cases where an engineer would be able to make very good use of a small turbine for auxiliary work, such as induced forced draft, driving small pumps or centrifugal blowers, and for a number of other purposes, that they are deterred from doing so by the discouraging lack of economy in small size turbines. For them the "Spiro" will undoubtedly put a new aspect to the matter, as it has been found under test to require no more steam per horse-power-hour than reciprocating engine of corresponding size. This places it at an advantage of from 20 to 50 per cent. over the ordinary single-stage, non-condensing turbine and opens up for it a large field, augmented by the small size of the combined outfit, whether pump, fan or other machine.

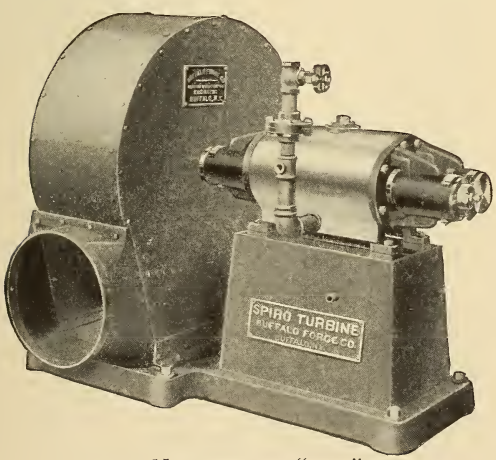
One of the illustrations shows a 10 horse-power "Spiro" direct connected to a 25-inch fan, which is at present furnishing forced draft, through Jones underfeed stokers, to 300 boiler horse-power under extremely severe conditions. The size of this outfit has never been duplicated, considering the boiler horse-power served, and the fact that the highest pressure carried on the boilers is only 90 pounds.

There are but two points of wear in the "Spiro" turbine—namely, the bearings and the tooth contact.

In the bearings, the lubricating system is so designed that each bearing acts as an individual oil pump, circulating oil through the bearing between shaft and bushing with a positive pressure. This forms a per-

fect oil film, and as long as there is any oil in the reservoirs or oil chambers which form part of each bearing this oil film is automatically maintained. Thus there is absolutely no metal-to-metal contact in the bearings, all the contact coming from the oil film. This may be proved at any time by running the turbine and then quickly shutting down and removing one of the heads. As long as this oil film is maintained—and it will be as long as there is oil in the reservoir—there will be no perceptible wear on the bearings.

The tooth contact must be said to be very satisfactory. The helical gears are the most perfect known for high-speed service, smoothly running, and of strength far beyond the requirements. The length of the spiral rotors in the "Spiro" is much greater than would be necessary for the face of spiral gears transmitting equal loads at equal speeds, and, as a result, the maximum tooth pressure per square inch is limited to five pounds, while ten times that amount would be conservative for long-wearing power transmitting gears. It has also been discovered that a film or cushion of steam is at all times maintained between the teeth of the rotors, which causes an elastic contact sufficient to produce great smoothness of action.



15-HORSE-POWER "SPIRO" DRIVING 40-INCH MILL EXHAUST

Tests made upon the "Spiro" turbine show the following results:

(1) Boiler pressure, 120 pounds; initial pressure, 101.5 pounds; horsepower, 23.3; speed, 2,450; water per brake-horse-power = 53.2 (non-condensing).

(2) Boiler pressure, 130 pounds; initial pressure, 115 pounds; horsepower, 151; speed, 2,710; water per brake-horse-power = 31.8 (non-condensing).

Possibly a still more striking example of the great power developed in a small space is furnished by a line of air drills embodying the "Spiro" turbine, which the Buffalo Forge Company has been developing, and which will shortly be put on the market. A ¼-inch drill will penetrate hard cast iron 1 inch thick in twelve seconds, or at the rate of 5 inches per minute. Hundreds of visitors have seen these drills at the shops of the Buffalo Forge Company and have expressed amazement at the fact that so much evidence of power can be produced from such small rotors. It proves that the principle of the "Spiro" turbine utilizes substantially all and wastes very little of the energy applied.

Mr. H. M. Byllesby, president of the H. M. Byllesby Company, recently gave an address before the students and faculty of the College of Engineering of the University of Illinois. His subject was "Organization in Engineering." As an introduction, Mr. Byllesby preached a brief sermon on the importance of work—of hard, continuous, never-failing, enthusiastic work. In discussing the business of public service corporations, he insisted that those who were responsible for the management of such organizations would need to take the public into their confidence. It was important, he said, that the public should know the difficulties and the injustice which, under modern conditions, often confront the officers of such organizations.

THE LATEST CATALOGUES

Steam-Driven Compressors

The Ingersoll-Rand Company, 11 Broadway, New York City, have issued a new catalogue, Form 3211, bulletin of 20 pages, descriptive of "Imperial Type X" Duplex Steam-Driven Compressors. The catalogue shows several views of machine in section, and gives tables of standard sizes and capacities. These machines have massive, well-braced structure, unusually generous bearing surfaces, mechanically-actuated air intake valves with large, direct passages, and cushioned discharge valves. The air cylinders of all "Imperial" compressors have water-jacketed barrels and heads, the latter being hooded for the admission of cool, clean air. The smaller compressors, up to 16-inch stroke, have overhung cylinders. On larger sizes the air cylinders are supported on a strong foot-piece resting upon a sole-plate on the foundation, and may be slid away on this sole-plate when it is necessary to detach the cylinder from the frame.

High-Duty Pumping Engines

Henry R. Worthington, 115 Broadway, New York City, has just issued Bulletin W-188, giving an extended description of the Worthington horizontal, triple-expansion, high-duty pumping engine installed in the Hope station of the Providence, R. I., Water Works. This engine has a capacity of 10,000,000 gallons per twenty-four hours against a head of 85 pounds per square inch, and its design represents the latest practice in pumping engines of this type. One of its especially interesting features is its high-duty attachment, involving the use of compensating cylinders taking the place of a flywheel. The arrangement is preferable to a flywheel, in that the power exerted increases in almost exact ratio with the decrease of the power of the expanding steam. The account given of the duty trials shows that the guaranteed duty was exceeded at full load by 4.5 per cent. and at reduced capacity by 12.5 per cent. The actual duty at full load was 149,500,000 foot-pounds per 1,000 pounds of dry steam. The bulletin also shows and describes a similar engine installed at Fall River, Mass. The bulletin will be especially interesting to municipalities facing the problem of securing adequate pumping service economically.

Gas Tractors

The Minneapolis Steel & Machinery Company, the largest manufacturer of machinery in the Northwest, and whose plant occupies over twenty acres of ground in Minneapolis, Minn., have recently issued a handsome catalogue entitled "Twin City 40 Gas Tractor."

The Twin City "Forty" is an all-steel gas tractor, in the design and building of which every effort of the company has been put forth to produce a perfect machine, regardless of cost, its design representing the product of the foremost gas tractor experts in the country. Every part of this tractor is made in the company's own plant, and has been subject to the most trying tests in the shop and the heaviest kind of work in the field.

This is a handsome, fully illustrated catalogue, and describes this gas tractor very fully, going into all details and explaining why their Twin City "Forty" bears the high reputation it does for service, efficiency and accessibility of its parts.

The steering mechanism of this tractor is unique in gas tractor equipment, the wheel turning on knuckles, while the axle remains stationary. It is claimed that this is the simplest, strongest and easiest steering device in use on a gas tractor. A copy of this catalogue may be obtained by addressing the company and mentioning CASSIER'S MAGAZINE.

New Publications of the General Electric Company

"Small Turbo-Generator Sets," Bulletin No. 4887, illustrating and describing the General Electric Company's turbo-generator sets in capacities of from 5 to 300 kilowatts. All of these sets are of the horizontal type, and can be arranged to operate either condensing or non-condensing, and at any steam pressure above 80 pounds for the smaller sizes and 100 pounds for the larger.

"Series Incandescent Lighting Apparatus," Bulletin No. 4900, is devoted to apparatus used in connection with series incandescent street lighting, and supersedes in part the company's previous bulletin on this subject. The bulletin is practically an ordering catalogue and contains no description other than that afforded by the illustrations. It lists lamp brackets of various styles (giving their dimensions), tungsten economy diffusers, G-E Edison Mazda street series lamps, constant-current transformers, switchboard panels and lightning arresters.

"GE-203A Railway Motor," Bulletin No. 4920, describing GE-203A railway motor, which is of the box frame, commutating-pole type, rated at 50 horse-power on 600 volts and 40 horse-power on 500 volts. The motor embodies radically new features of construction, which have been developed with a view to effecting greater economy in railway motor operation, and it is considerably lighter per horse-power output than the previous design.

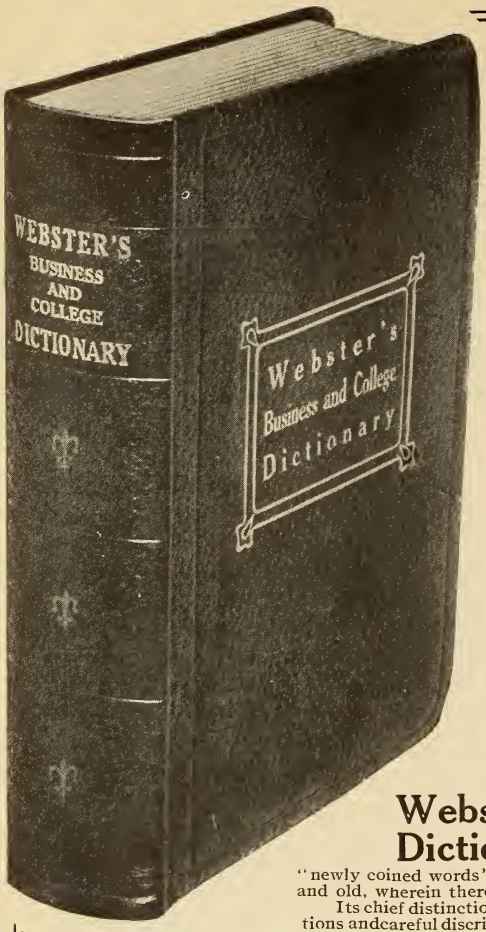
"Direct Current Switchboards" of the General Electric Company are described in Bulletin No. 4918, recently issued, which also illustrates and describes panels designed for general use in central stations. The list of panels contains both generator and feeder types, and the panels are made for 125, 225 and 600 volts.

Suction Gas Producers

Illustrated booklet issued by the Amsler Gas Power Company, Wabash Building, Pittsburg, Pa., describing their Type C Amsler suction gas producer. Features claimed for this gas producer are: high economy, uniform quality of gas, control of quality of gas, simplicity of construction, and safety. This gas producer is guaranteed to operate successfully on anthracite coal of pea or buckwheat sizes, coke, coke breeze, or charcoal, and to deliver 80 per cent. of the heat units in the fuel in a clean gas free from tar or dust in harmful quantities. The book also contains the report of a test made of this producer by Prof. W. Trinks, of the Carnegie Technical Schools, of Pittsburg, Pa.

Miscellaneous

Among other publications recently issued, and which can be obtained by addressing the company issuing them and mentioning CASSIER'S MAGAZINE, are: "Regulating Valves," Ziermore Regulator Company, Johnsonburg, Pa.; "Column Selector for Typewriters," Remington Typewriter Company, describing this device, to be found in new Model 10, which does away with all hand letter spacing of the carriage; "Expanded Metal Construction," Northwestern Expanded Metal Company, Chicago, Ill. The first issue of a bulletin to be issued at frequent intervals, and devoted to the constantly expanding use of expanded metal in building construction and cement work. By writing the company direct copies will be mailed free. "Scientiffc Management in the Office," an interesting and instructive book on modern office methods, designed to save both time and money, issued by the Shaw-Walker Company, Muskegon, Mich., which contains many points of value to all whose work has anything to do with office management, either of a small office of their own or that of a large company.



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A First-Class UP-TO-DATE Dictionary

FRANCIS H. STILLMAN

FRANCIS H. STILLMAN, president of the Watson-Stillman Company and a prominent figure in the engineering world and machine tool industry, died suddenly on February 18 of intestinal hemorrhage, at his late residence, at Brooklyn, N. Y. The day before his death he was at his office as usual and apparently in the best of health.

Mr. Stillman was born in New York on February 20, 1850, and was the only child of Paul Stillman, who was connected in an official capacity with the famous Novelty Works, which in the early fifties of the last century was the principal machine shop of New York.

It was in the schools at Mystic Bridge, Conn., that Mr. Stillman obtained his early education, and from there he entered Milton College, Wis. He followed the plan advocated by eminent educators at that time of interpolating a course of shop training between academic courses, and took an apprenticeship course in the shop of the Cottrell & Babcock Printing Press Works, at Westerly, R. I., afterwards entering preparatory classes in the Cooper Union, passing from there to the Sheffield Scientific School of Yale University, and graduated with the degree of B.S. in 1874.

In the meantime, the first patent for a hydraulic jack had been taken out by Richard Dudgeon, with whom was associated Mr. E. Lyon, the stepfather of Mr. Stillman. In 1880 the firm of E. Lyon & Co. was formed, consisting of Mr. Lyon, Mr. T. H. Watson, long associated with Mr. Lyon during the latter's manufacturing career, and Mr. Stillman. Upon the death of Mr. Lyon, in 1883, Mr. Stillman organized the firm of Watson & Stillman, to conduct the business of manufacturing hydraulic jacks, presses and other hydraulic machinery. This firm was incorporated in 1904 as the Watson-Stillman Company, and Mr. Stillman remained its president up to the time of his death. Under his direction his firm early became prominent in the hydraulic engineering field, and Mr. Stillman was at the time of his death perhaps the most prominent American engineer on hydraulic machine-tool construction, while his firm has built upwards of 4,000 different types and sizes of hydraulic machines and now has a large and active plant at Aldene, N. J.

Mr. Stillman was a member of Hyatt Lodge, F. and A. M., a Knight Templar of Kismet Temple, Mystic Shrine, a member of the Royal Arcanum, a member of the Hanover Club, of Brooklyn, N. Y., the Engineers' Club of New York, the American Society of Mechanical Engineers' Club of New York, The Amerin which he always took a most active part, serving on its finance committee as member and then chairman. He also served on the membership committee from 1903-5, and his work was considered so valuable that when his first term expired he was reappointed and made chairman, and was again reappointed and elected chairman in 1906, serving as such until 1911. He was treasurer and continuously through its existence a director of the National Association of Manufacturers; he organized and was the first president of the Machinery Club of New York, and was also first president of the National Metal Trades Association.

In addition to being president of the Watson-Stillman Company, at the time of his death he was also president of the Bridgeport Motor Company and of the Pequannock Commercial Company and a director in other manufacturing firms.

Mr. Stillman's affable disposition, high standard of business integrity and kind personal interest in all those with whom he came in contact won for him a large circle of friends, who will keenly regret their loss in his death.

His funeral services were held at his late residence in Brooklyn on Tuesday, February 20, and he was buried at Evergreen Cemetery the following day.

A portrait, with biographical sketch, of Mr. Stillman was published in the issue of this magazine for April, 1908.

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THE OPPORTUNITIES OF THE UNITED STATES IN SOUTH AMERICAN COMMERCE

By Francis Washburn Hoadley

TRAIN ON TRANS-ANDINE RAILROAD, SHOWING SNOW SHEDS

IT is only within recent years that the United States has appreciated the wonderful possibilities for trade development afforded by South America, and that the great country to the southeast of us is, and should be, an active zone for our industry, commerce and trade.

One has but to look at a school text-book of a comparatively few years ago, from which the man of middle age to-day absorbed his first impressions of South America, to realize how little the American writer of such works at that time understood the importance of South America; and, strange as it may seem, even at the present time many view that country through the lenses of their early studies.

Ask nearly any man and he will say that South America lies south of the United States, the fact being that it is so far to the east of us that the meridian of the Atlantic States passes along the Pacific Coast of South America, so that New York on the Atlantic and Valparaiso on the Pacific are on the same north and south line.

This nearness of the East Coast of South America to the Continent of Europe has had much to do with the great trade built up between the

latter and the former; at the same time, there is another important factor which must be taken into consideration: the aid given by the countries of the Old World, especially Germany, to the expansion of their South American commerce.

A good illustration of this is afforded by the following statement made by Mr. Alfred J. Thompson, president of the American Infusion Steel Process Company, who for many years was actively engaged in the introduction of American machinery in Latin America:

"I have personally met two representatives who report directly to the Kaiser, who are commissioners and patrol the whole West Coast of South America—see the man, see the buyer, see the banker, see the man who extends credit, and so on; hear his story, get him interested, and give him individually the financial and moral assurance of the German Government."

It is largely through the never-ceasing aid of all kinds extended by the German Government to its people that Germany has built up her large South American commerce. In Colombia alone, well in advance of the opening of the Panama Canal, Germans by the thousands are settling and preparing for the great activities and opportunities the opening of the canal is sure to bring.

That the United States is awake to the importance of the South American market, however, is indicated by the fact that during the five years' period of 1907 to 1911 her total exchange of commerce, exports and imports with Latin American countries has grown approximately from $498,000,000 to $640,000,000, an increase of $142,000,000, of which sum the exports from the United States represent an increase of $65,000,000 and exports from these countries to the United States $77,000,000.

Though the United States is today adding to its trade in Latin America as rapidly as is Great Britain, Germany or France, such has been far from the case in former years.

The opportunities for the extension both in the export and import trade of the United States in South American countries in proportion to the population of the countries concerned are greater than they are in any other part of the world. No group of countries can, in proportion to their population, require more of

CITY OF RIO DE JANEIRO

HARBOR OF RIO DE JANEIRO

the manufactured products of the United States, nor furnish in a larger degree the products needed for American industries and food supply.

Two things essential to the development of this great market by the United States are an abundance of direct steamship lines to South American ports and ample banking facilities in direct relation to the financial institutions of the United States. There are already a number of sailings from Gulf ports to the East Coast of South America and four lines from New York to the Isthmus of Panama, besides three regular lines running from New York to the West Coast by way of the straits, as well as some others which run to the East Coast only, and doubtless greater facilities will be furnished to meet greater demands as they arise. Freight rates are very reasonable at the present time, and indeed it is stated that it costs no more to get a ton of cargo down the entire Atlantic Coast, through the Strait of Magellan and up the Chilean coast again than it does to transport it from New York to Galveston or New Orleans. It is impossible to predict what changes will follow the opening of the Panama Canal, but the saving in time at least should be a matter for consideration.

So far as banking facilities are concerned, these must naturally follow the investment of American capital in South American enterprises, just as the present financial arrange-

GLACIERS IN THE STRAIT OF MAGELLAN

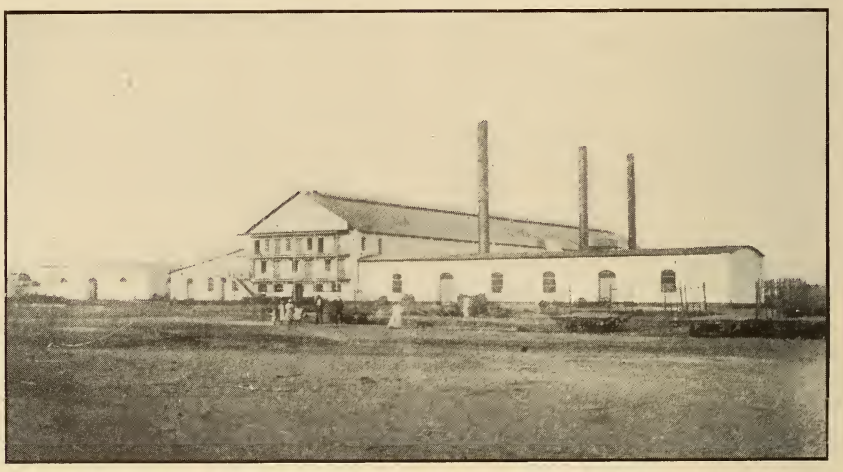
ments are the result of the large investments of British, German and other funds in the industries of the country.

Both of these elements in the development of commercial relations between North and South America must depend upon a revision of the shipping laws of the United States and upon the actual investment of American capital in South American industrial enterprises.

That these features should be developed, and developed quickly, is most important; for, once the Panama Canal is open, the wonderful, potential and extensive coast line from the Mexican-California boundary to the Strait of Magellan, 8,000 miles forming the Pacific side of Latin America and including twelve countries, Mexico, Guatemala, Salvador, Honduras, Nicaragua, Costa Rica and Panama in North America, and Colombia, Ecuador, Peru, Bolivia and Chile in South America—a coast line in the very infancy of its commercial and natural development—will be open for direct approach from the Lake section and the Central and Eastern portions of the United States; and without doubt the opening of the Panama Canal will mean for that 8,000 miles of coast the same kind of development which the Pacific Coast States of the United States experienced following the construction of the first trans-continental railroads.

A conservative estimate indicates the growth of the commerce of this new territory within ten years to more than $1,000,000,000, and, provided the United States possesses proper shipping facilities, there is no reason why it should not have the largest share.

A pioneer house engaged in trade between South America and the United States, and one which has long had large interests on the West Coast of South America, is W. R. Grace & Co., of New York, N. Y., and in view of its long and successful career it is only natural that it should promptly realize and prepare for the greatly increased trade that will follow the opening of the Panama Canal.



SUGAR FACTORY AT CARTAVIO, IN CHICAMA VALLEY, IN PERU. W. R. GRACE & CO.

The founder of this firm, Mr. W. R. Grace, whose portrait appears as a frontispiece to this issue, had many years' experience in Peru, and as early as 1885 was junior partner of Bryce, Grace & Co., of Callao, Peru, one of the most prosperous firms on the West Coast, and which later became the firm of Grace Brothers & Co.

The New York house of W. R.

COTTON FACTORY AT VITARTE, NEAR LIMA. W. R. GRACE & CO.

Grace & Co. was founded in 1865, in which year Mr. W. R. Grace came to New York with a fortune made in South American commerce. He took an active interest in its development and brought to bear on its policies the great experience he possessed of South American affairs. This New York house engaged in a broad field and rapidly established very good European connections, prospering and constantly enlarging its business.

Mr. M. P. Grace, the younger brother of W. R., and who was a partner in the firm of Grace Brothers & Co., mentioned before, had the affairs of this American house in his hands for years. In 1879 Peru became very much embarrassed financially, due to the failure of Dreyfus Brothers, who had the monopoly of the exportation of Peruvian guano, and the reorganization of the finances of that country was undertaken by Mr. M. P. Grace, who settled an indebtedness

AVENIDA DE MAYO, BUENOS AIRES

of about $250,000,000, and, taking over the construction of the Oroya Railroad—the work on which had involved the Peruvian Government very deeply—he carried it to a successful issue.

Appreciating as this firm does the need of steamers from New York to South American ports direct, it is adding to their present fleet by building three new steamships for the West Coast trade, and when these are in service it will have a fleet of twelve vessels of an average burden of 10,000 tons engaged in trading between New York and such ports. A tri-monthly service will be maintained by them by that route as soon as the canal is opened. It is of interest to note in this connection that W. R. Grace & Co. were the first to send a steamship from New York through the Strait of Magellan. This was done in 1890, and a regular line of steamers was established by them in 1893.

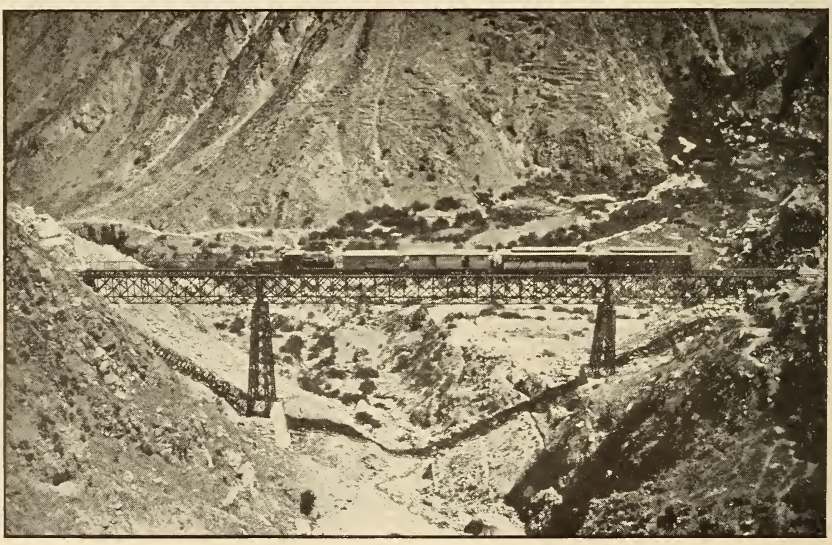
Mr. J. L. Schaefer, vice-president of the firm of W. R. Grace & Co., states that at present they are taking down to South America all kinds of goods, machinery, steel products, kerosene, lumber, rough cotton goods, wire nails, etc., and also large quantities of agricultural machinery and a great many electrical appliances.

This firm is also largely interested in manufacturing in South America, owning and operating sugar factories in the Chicama Valley, in the central portion of Peru, as well as estates of about 25,000 acres, the sugar factories being valued at about $1,500,000.

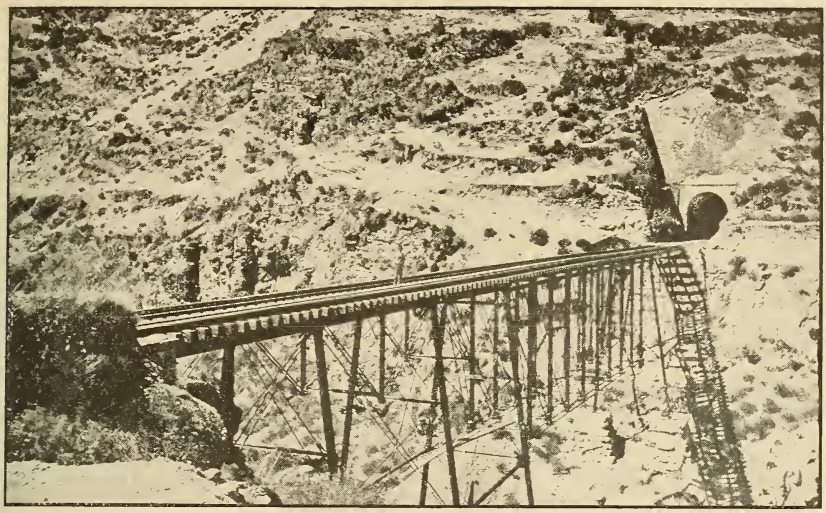
They also own cotton factories situated in Lima, the first mill having been built about twenty years ago, one of the others ten years ago, and the latest one five years ago. Here they take the cotton right through; they spin, weave and bleach, and also produce a considerable amount of raw cotton, this investment being about the same as that in sugar.

In railroad construction and operation as well, the firm of W. R. Grace & Co. has large interests. In addition to completing the Oroya Railroad, they completed, about a year ago, the Trans-Andine Railway, which, though but 120 miles long, represents an investment of about $10,000,000, all the construction work on this line having been done at an altitude of between 9,000 and 12,000 feet through a mountainous country involving many engineering difficulties.

In Bolivia they are interested in the Bolivia Railway Company. Of



VIADUCT ON OROYA RAILROAD, WITH TRAIN

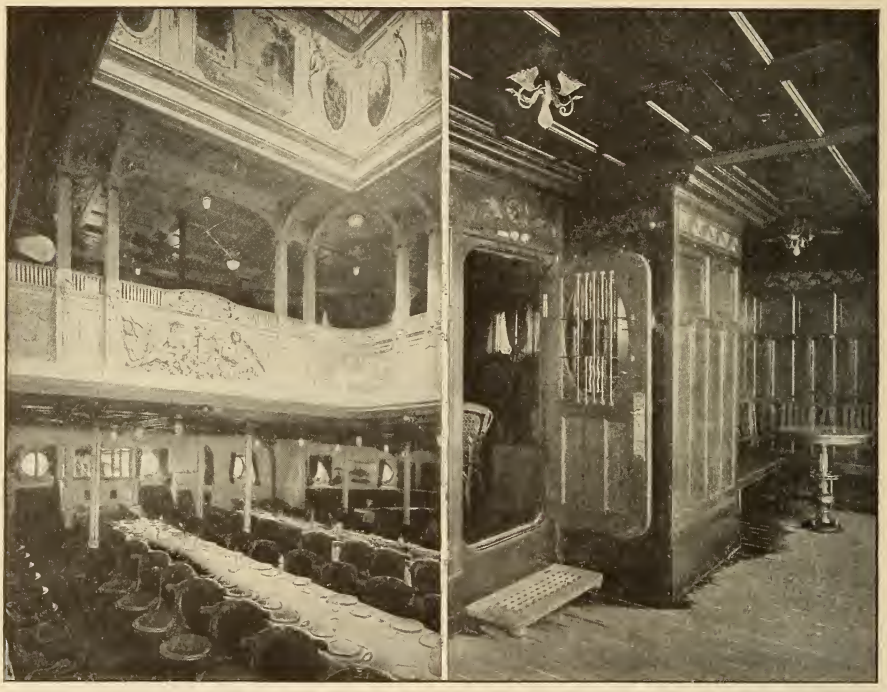


VIADUCT ON OROYA RAILROAD, SHOWING TUNNEL

the twelve hundred miles contracted for, four hundred are finished, and the work is proceeding; in several coast towns they have built street railroads and started electric lighting plants, and they maintain offices in every important port on the West Coast.

In Uruguay the unlimited water-power for generating electrical energy is to be utilized in the near future. This Republic is intersected by a system of waterways of varying importance; of these, the Uruguay River is most important. This river consists of channels and lakes practically without current at low water, with a rise at high water of 46 feet above the average level. The plan proposed for utilization of the power generated by means of lateral channels fifteen miles above Salto is an extensive one, as it is intended to transmit the electric current to Buenos Aires, Salto, Paysander and many other centres. The benefits to follow this great undertaking will be many, as the reef near Salto will be

S.S. "BLUECHER," HAMBURG-AMERICAN LINE



Dining Room

Sheltered Corner on Deck

S.S. "BLUECHER," HAMBURG-AMERICAN LINE

removed, thus greatly extending river navigation.

Up to the present time very little American capital has gone into development in Uruguay. English capital and enterprise have performed the railroad development of the River Platte. At present, however, American railroad enterprise is engaged in the construction of over 400 miles to connect Colonia with the terminus of the railroads in Brazil. Practically all the material used in the construction of this road, the Pan-American Trans-Continental Railway, are American. The steam shovels used were built by the Marion Steam Shovel Co., of Marion, Ohio; the passenger cars came from the Jackson & Sharpe Mfg. Co., Wilmington, Del.; the freight cars come from Middleton, Pa., and the rails are from the United States Steel Corporation. Even a cargo of ties of Louisiana oak has been shipped down from New Orleans, the first American ties ever used there. This road will cost from $13,000,000 to $14,000,000, and to date more than $1,000,000 has been expended in its construction. Work was started on this road in July, 1911, and it is expected to be completed in about four years, when it will be the last link in the railroad planned many years ago to connect the four chief capitals of Southern South America, Valparaiso and Buenos Aires being connected by the Chili-Argentine Railroad, which, practically speaking, also connects Montevideo; and this new road from the Argentine border to the boundary of Brazil will give through communication with Rio de Janeiro.

Mr. José Richling, Consul-General of Uruguay in New York, states that there is a brisk demand in his country for goods peculiar to the United States.

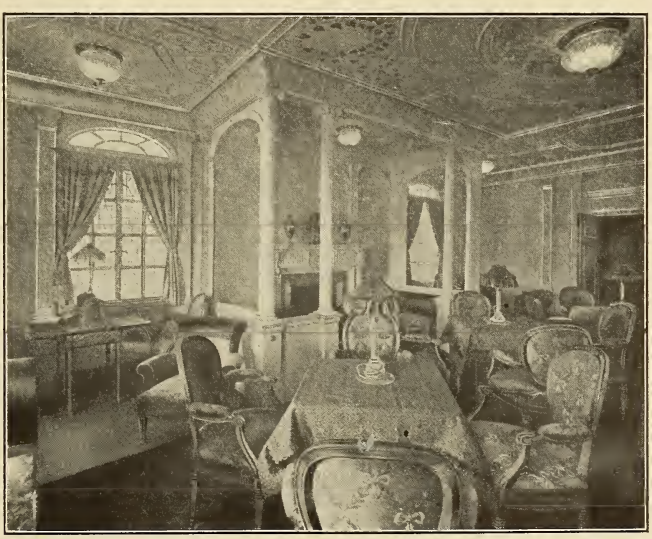
During the last ten years the construction of railways in the State of Sao Paulo has increased by nearly

S.S. "LAURENTIC," WHITE STAR LINE

one thousand miles, and the extension of several lines has tended to increase the trade in American railway accessories, this being especially true of railway cars, locomotives and rails.

The city of Sao Paulo itself stands at a height of three thousand feet, and is without a river or harbour, its port—Santos—being sixty miles away; yet it is the second city in Brazil, and one of the wealthiest and most beautiful in South America. Its population numbers 300,000, and it possesses seventy-five miles of electric lines.

European manufacturers are aided by constantly improving transportation facilities between the continent and South America, but up to the present time the United States has given little aid to her own producers who are trying to obtain a share of the growing commerce of



READING AND WRITING ROOM, S.S. "LAURENTIC," WHITE STAR LINE

that region, and who have largely to depend on foreign ships, often controlled by European competitors. The business man of Europe can send and receive South American mail almost daily, while a semi-monthly service is the best that is afforded his American competitor.

Taking into consideration the tremendous advantage of European shippers, it is remarkable that American shippers have been able to obtain as large a trade as they have. For example, the volume of trade obtained by American shippers in the River Platte district and the increased exports from America to those countries, despite the handicap of inferior transportation facilities, can be taken as a strong indication of what the volume of American exports to South America would be if American exporters had the benefit of such excellent transportation facilities as are enjoyed by their European competitors, facilities which enable the latter to meet and surpass them with goods of inferior quality.

There is, perhaps, no cause which has done more to awaken the American people to the importance of South America than the cruises and tours which have been conducted for the last few years by several of the large transatlantic steamship companies.

For several years the Hamburg-American Line has been conducting cruises to South America, which have been availed of by large numbers of Americans and have proved most enjoyable and instructive. These tours include visits to Brazil, Uruguay, Chile and Argentine, sixteen ports of call being made altogether, covering 19,039 miles, and take in the East Coast of the continent, the town of Punta Arenas, in Chile, and the West Coast as far north from the Strait of Magellan as Valparaiso. For this service the S.S. *Bluecher* is used, a vessel well suited for the purpose and affording every comfort. Especially constructed as she was for service in Southern waters, her staterooms are commodious and homelike. She is 525 feet long, 60 feet wide, with a depth of 45 feet, and is equipped with two sets of quadruple-expansion engines which develop 8,000 horsepower. A feature of this tour is the chance afforded the tourists to take the overland trip across the continent from Valparaiso to Buenos Aires by the way of Santiago and the Trans-Andine Railroad, and then rejoin the *Bluecher*. This is the railroad spoken of before in

S.S. "ARCADIAN." YACHTING CRUISER DE LUXE, ROYAL MAIL STEAM PACKET COMPANY

this article as having been completed about a year ago by the firm of W. R. Grace & Co. and the construction of which represents some remarkable engineering feats, the Andes Mountains having been tunneled through to connect Chile with Argentine. This tunnel being at the highest point in the road, is 3,460 yards long and 10,000 feet above sea level. This tour lasts eighty days from New York and back, and affords a rare opportunity for inspecting the beauties and developments of South America.

For those who lack time to spend in the circumnavigation of South America the tours of the White Star Line, lasting thirty-one days, afford a chance to visit some parts of Latin America, as Cuba, Haiti, Jamaica, Panama (Colon), Colombia, Venezuela and several of the West India islands.

The White Star Line uses the new triple-screw S.S. *Laurentic* for this service, a vessel of 14,892 tons register, equipped with engines of a combination of turbine and reciprocating types, and possessing spacious promenades and a perfect ventilation system.

The Lambert & Hill Line operate fine steamers direct between New York and Rio de Janeiro and Buenos Aires, and the Royal Mail Steam Packet Line conducts numerous excursions to many ports in the Caribbean Sea and to Panama.

No sooner had the treaty been signed which insured the building of the Panama Canal than this latter line started a system of expansion and acquired other lines reaching this most productive country, which is sure to come into its own with the completion of the canal; and this line to-day owns or controls six steamship lines operating 295 steamers, while other ships are either in course of construction or planned.

For the time when the Panama Canal is opened the Royal Mail Steam Packet Line is considering plans for a line which will run from New York through the canal direct

CABIN ON THE "ARCADIAN," WHICH IS FITTED THROUGHOUT WITH BEDSTEADS, INSTEAD OF BERTHS, THERE BEING NO BERTHS IN THE SHIP

to Valparaiso, and another from Valparaiso through the canal to Vancouver, British Columbia, with stops along the points of the Pacific Coast of the United States and a probable line of mail steamships from Europe through the canal to Australia, China and Japan.

Not only in building new ships and acquiring additional lines is the Royal Mail Steam Packet Line preparing for the future trade of South America, but is constructing wharves and piers and making preparations for transferring the great amount of freight from interior points of South America to tide water.

In conclusion, it may be said that at present the United States is at a crucial period of its commerce with the Republics of South America, Republics in which there is such a large and growing demand for the many articles manufactured in the United States—a demand which we are so well able to supply as to require an abundance of convenient and frequent transportation by direct steamers between the United States and South America.

DINING ROOM OF THE "ARCADIAN," SHOWING THE GALLERY WHERE DINERS ARE ALSO SERVED

THE EFFICIENCY SOCIETY

SEAL OF THE EFFICIENCY SOCIETY

THE Efficiency Society, of which mention has been made in these columns from time to time during the past few months, came to its own on Monday and Tuesday, March 18 and 19, by two full-day meetings in the large auditorium of the Engineering Societies' Building, 29 West Thirty-ninth street, and a dinner on the evening of Monday in the banquet hall of the Aldine Association, in the Fifth Avenue Building, at Twenty-third street.

The Society's membership had exceeded 800 at the time of the meeting, and a very large number of applications were received during the meeting, so that, after they have been passed upon by the membership committee, considerably over 1,000 members will have been enrolled, "which," as Mr. Henry R. Towne, chairman of the membership committee, stated in his report, "is a much larger number than any of the other national societies started out with and augurs well for the success of the new movement."

The programme announced that "Efficiency is the ratio of result obtained relative to the amount of expenditure in obtaining it. This applies to human as well as mechanical agencies. With these agencies in the various fields of endeavor the Society will deal. This meeting will be confined to a study of the application of efficiency to the industrial and commercial fields."

In the absence of the chairman of the organizing committee, Mr. James G. Cannon, president of the Fourth National Bank, the meeting was opened at 10 o'clock by a few words of greeting by Mr. Henry R. Towne, who outlined the purpose in the minds of those who had inaugurated the movement, and immediately afterwards the business of organizing the Society was taken up, the Constitution and By-Laws were adopted, and the following directors were elected:

Bion J. Arnold, Chicago, Ill.
Roger W. Babson, Wellesley, Mass.
W. C. Brown, New York, N. Y.
James G. Cannon, New York.
M. E. Cooley, Ann Arbor, Mich.
W. W. Freeman, Brooklyn, N. Y.
W. F. M. Goss, Urbana, Ill.
Luther H. Gulick, M.D., New York, N. Y.
William McConway, Pittsburg, Pa.
H. R. Hatfield, Berkeley, Cal.
Melville W. Mix, Mishawaka, Ind.
Isidor Straus, New York, N. Y.
Henry R. Towne, New York, N. Y.
George Westinghouse, East Pittsburg, Pa.
Schuyler S. Wheeler, Ampere, N. J.

These met later and elected Mr. Cannon president. As all of the directors were not present, the election of other officers was postponed to a later meeting. The name of the Society was adopted, and a badge, of which the design is shown above, was submitted to the directors.

The morning having been set aside for organization purposes, the rest of the meeting was divided into four sessions.

The afternoon session was devoted to a symposium on organization, as follows:

How Efficiency Should Benefit the Employer, the Employee and the Public. Dr. John A. Gray, University of Minnesota.

The General Principles of Organi-

(Continued on page 79.)

Mechanical Efficiency

THE transmission of power by means of the so-called "wrapping connectors" is a very old method, and, when properly designed and installed, it is a very efficient method. Several things are necessary to make it satisfactory, and it is far from being the very simple thing which it appears. Whole treatises have been written about the use of belting and pulleys, and even yet there exists a wide discrepancy in many cases between the theory and the practice in the application of belt transmission.

As a result, much of the practice of power transmission of this kind has been evolved from long experience, and it is to that experience even now that it is necessary to look for guidance if installations of maximum efficiency are to be attained. This is especially true in the use of rope as the wrapping connector between two rotating shaft systems Although rope doubtless preceded leather belting as a means for power transmission, it was limited to comparatively small capacities until its advantages began to be realized, and then two methods were developed to enable the capacity of a single rope to be multiplied and thus increased.

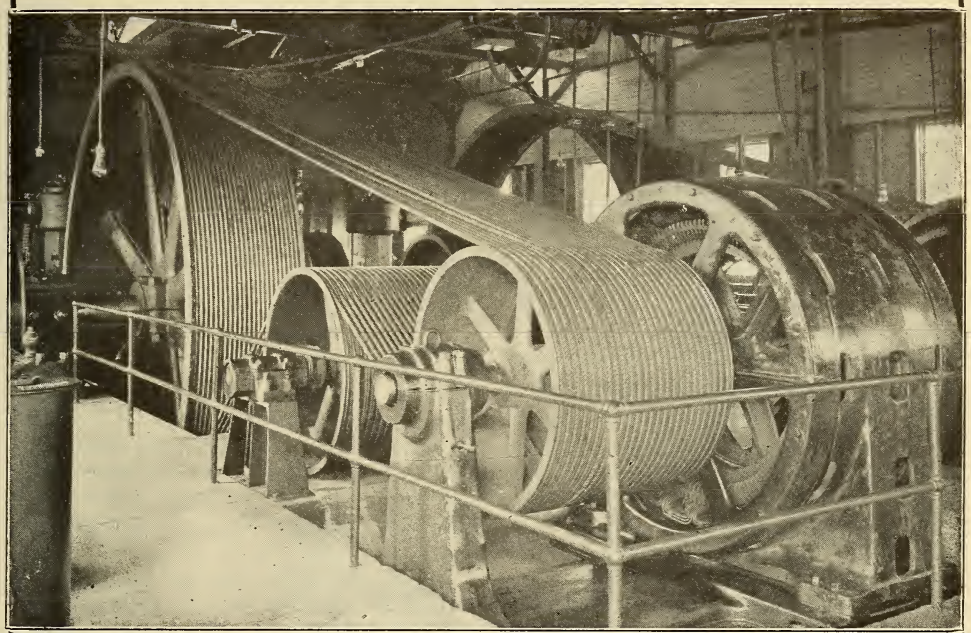
The first and apparently simplest plan was that adopted originally in England, and termed the English system, this amounting merely to a repetition of the single rope and using a number of ropes, each in its own groove, upon the common sheave. The only thing which made these separate rope drives work together was the fact that the grooves in which they operated were formed in the perimeters of the same sheaves. If it were practicable to be assured that each of these independent ropes were maintained at the same tension and that each rope was carried at the same depth in the groove as every other rope and thus operated in a perimeter of the same diameter, a fair degree of uniformity in power transmission might be attained by this plan. The impracticability of maintaining these conditions, together with other practical objections, led to the development of the so-called American system, in which a continuous rope is conducted around the sheaves a number of times and then led off over a guide and tension sheave, which insures the proper tension upon all the turns and places the entire transmission under positive control.

From its origin, nearly thirty years ago, down to the present time, this method of transmitting power from one rotating member to another has maintained its position, and notwithstanding the development of other methods of power transmission, the continuous rope drive is accepted as standard.

It should be understood, however, that this, or any other method of transmitting power from prime mover to tool, forms but a single element in a series of devices. A transmission by pulleys or grooved sheaves includes by inference the shafting upon which the pulleys are carried and along which the torque must pass. The shafting demands pillow blocks, hangers, bearings and lubricating methods, and these, again, require proper support and methods for assuring and maintaining alignment. Proper control of motion means powerful and effective clutches, and since the efficiency of such a system is represented by the continual product of the efficiencies of these several elements, the entire series should be designed to be operated together, treated as a whole, and assembled and tested in united action, so that the complete mechanism of transmission should be known in detailed operation.

When the transmission of power is given such scientific attention, both as to design and execution, the maximum efficiency possible may be obtained, while under any other conditions the effectiveness of one portion may be almost wholly neutralized by the defectiveness of its neighbour.

DODGE



Dodge Rope Drive and Heavy Engineering in Perfect Operation Since First Revolution

TWENTY-EIGHT YEARS OF ROPE DRIVING

ROPE drives, correctly planned, are the most satisfactory form of transmission for a great many factory situations—

But successful, economical rope drives represent many intricacies of design learned only through long experience.

We have been designing, making and installing rope drives under the Dodge American system for twenty-eight years. We know the high efficiency that can be secured from them, and we know the essentials of design and manufacture that are necessary to secure this.

Hundreds of our rope drives are operating in all sorts of plants, under all sorts of conditions. Operating with minimum friction loss, noise and maintenance expense, and meeting every requirement.

The excellence of our designs, as worked out by men of capability and reputation, has been demonstrated time and again.

As specialists in machinery for the mechanical transmission of power, we are in a position to advise with you on any of your transmission problems.

Simply send us information and sketches showing the conditions to be met and secure our plans for consideration.

We have unusual facilities for the manufacture of belt and rope wheels up to 24 feet in diameter, heavy pillow blocks and bearings, friction clutches, etc., and complete transmission outfits.

Our experiences in rope driving have been put in book form. This contains valuable information on the subject. The book is 9 x 12 and contains 104 pages. It is selling for $1.00. However to managers, superintendents, master mechanics and chief engineers who are interested, we will be glad to send it with our compliments.

Dodge Manufacturing Company, Mishawaka, Ind.

Branches and Warehouses Carrying Complete Stocks of Dodge Transmission Goods:

New York, Cedar and Washington.
Cincinnati, 126-128 W. Third St.
Chicago, 202-214 S. Clinton.
Boston, 137-139 Purchase.
Brooklyn, 37th St. and 2d Ave.
Minneapolis, 202-04 Third St. S.
Pittsburgh, 337 Second Ave.
Atlanta, 54-60 Marietta St.
Philadelphia, 815 Arch St.
St. Louis, 507 N. Main St.

Over 200 Stock-Carrying Agencies in other Leading Trade Centrers.

Business Longsightedness

THE rock drill, from the beginning of its modern and successful career in mining and tunneling work, has been almost entirely the creature of the air compressor. The builders of the one quite naturally became the builders of the other also, and the business in both lines has grown, with one firm at least, to enormous proportions, and with every assurance of not only permanent but also of continually increasing activity. Quite naturally, there should be great unwillingness to interfere with the strong, deep flow of such an established business.

The air-driven rock drill has had no successful rival in its special field up to the present time, and it might be expected that if one should appear every known defensive device would be arrayed to resist the attack, and aggressive measures for its annihilation might be looked for. Electricity, with its omnivorous and pushing instincts, has continually sought its share in the rock-cutting work, but with little promise of success by any direct attack. All that has been required to be done defensively by the air-driven rock drill and the air compressor interests thus far has been to leave it alone.

But the electric air drill, which now comes upon the stage, is an entirely different proposition from any which have preceded it. This is a mechanical compromise, with no surrender on either side. The drill piston in the electric air drill is actuated by air pressure as completely as any drill piston ever was, but the motive power behind the air is electric, and the big air compressor is ignored and forgotten.

Talking now only of the apparent possibilities of the case, the coming of the electric air drill must have meant something ominous to the established workers in the older lines. It apparently threatened a revolution in methods of working and a superseding of the old line of machinery, with all which this might mean to the manufacturers who had hitherto supplied the market. In the presence of the new drill the old central compressor plant is useless, and how must it strike the compressor builder?

Valuable and revolutionary inventions have before this been killed, or held back for years, in the interest of established businesses, and we might well believe that in this case the temptation may have appealed with force. The patents are secure and ample to cover completely all the essential features of the new system, so that, as new inventions go, and as the inventors of disturbing things are apt to know, it would have been a simple and an easy matter to have first obtained control and then to have put the whole thing, not where it would have done the most good to those it was fitted to work for, but where it would have done the least harm—or none at all—to firmly established manufacturers.

Nevertheless, in this case the builders of the old are the builders of the new, and they are apparently going into this branch of the business and pushing it, as is their wont, "for all it is worth."

There are, of course, different ways of looking at this. There are those, we know, who would regard it as an exhibition of business folly or shortsightedness, who would have thought it much the wiser to have held securely the business already in hand, the current apparatus already doing well enough for all concerned, both in performance and profits.

The other view is, after all, undoubtedly the correct one. A manufacturer, or any business man, must in the long run be true to the permanent customer. When a firm has gone along for years continually making its product more efficient, reliable, desirable, the only thing for it is to keep on doing so; and though the possible changes as they come along may seem quite revolutionary, if they bring the same promise of increased efficiency that fact should determine their adoption.

Read What Was Done in This Case With An "ELECTRIC-AIR" DRILL

A big cement quarry had been using steam drills in a hard black flint limestone, putting in 35 to 40 feet of hole per drill in a 10-hour day, with a man and a helper to each drill.

They now have five "Electric-Air" Drills, each one of which is putting in 90 to 100 feet of hole (holes 2 to 6 feet deep) in a 10-hour day, with one man (no helper) to a drill.

Just figure for yourself what a similar saving in time and labor would mean in **your** work. It's worth investigating, isn't it?

NEW YORK **INGERSOLL-RAND CO.** LONDON

Offices in All Principal Cities of the World

COMPRESSORS ROCK DRILLS COAL CUTTERS PNEUMATIC TOOLS

Machines for Making Machines

ONE of the interesting things about the development of a new industry, such as the bicycle, the automobile, or the flying machine, appears in the influence exerted upon the tools by which the new product is made.

A notable example of this influence appears in the manner in which the tremendous business developed in the past ten years in the manufacture of automobiles has caused a corresponding development in the production of the forgings which go into an automobile, especially the drop forgings. An industry already well known and a process extensively used have been stimulated to a marked degree by the requirements which have been made for forgings of intricate form and high quality. The drop hammer, by which such forgings are made, has been improved, strengthened and increased in capacity to meet the demands, and both the board drop type and the steam drop hammer have been perfected to a wonderful extent, simply because there came a demand for an immense amount of work of an important kind to be done by such machines.

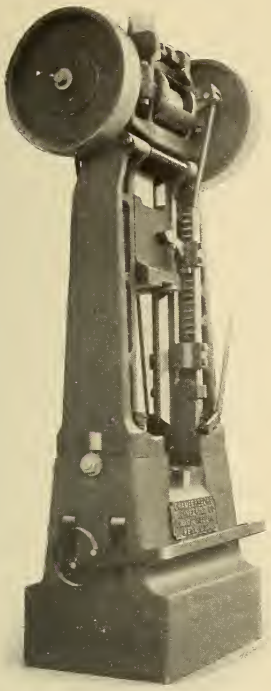
The board drop hammer was the pioneer tool, and while in most cases it is used more particularly for forgings on which there is but a small amount of "breaking down" to be done to the stock, as the side strains were very hard on the hammers as usually built, there are now in service board drop hammers of special design which are extremely rigid throughout, and so designed that the usual troubles, such as breakage of front rods, due to crystallization, and the difficulty of replacing broken adjusting bolts for the frame, have been obviated. Such modern hammers are also capable of being operated at a higher speed than formerly, with a resulting increase in production.

The steam drop hammer has also been wonderfully improved, and, in fact, such hammers as built to-day resemble those of ten years ago only in their general construction, as the details have been perfected to a wonderful extent.

Owing to the speed at which it can be operated and the fact that the force of the steam is used to increase the blow, the steam drop hammer is used to a much greater extent than the board hammer for heavy work and greater output, and has taken its place in many instances. However, there are many cases where steam is not available or where the work is such that the board drop can be used, and it is for these cases that the new board drop hammers have been built.

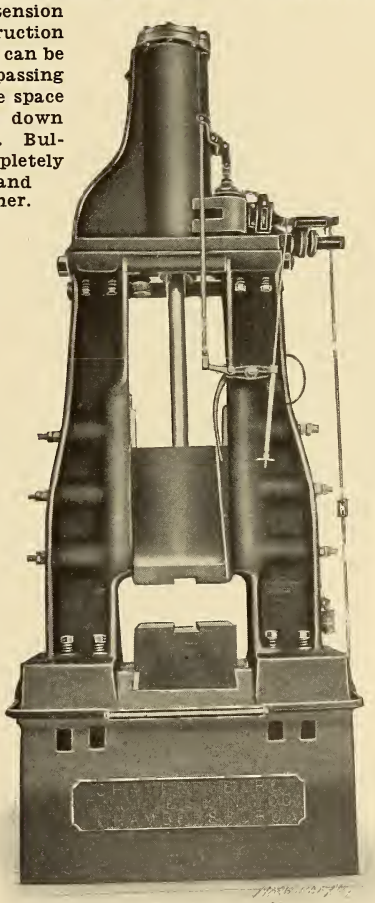
Board drop hammers have been found most efficient in sizes up to and including 2,000 pounds falling weight, although they are built up to 3,000 pounds falling weight. In the steam drop hammer, however, the size of the hammers has steadily increased to keep step with the larger work, and where but five years ago the average work was done on the 1,500 pounds to 3,000 pounds hammer and a 5,000-pound steam drop hammer was considered a large hammer, to-day seven and eight-ton hammers are being used for the heaviest work, such as axles and crankshafts for the motor trucks and gasoline tractors, and the average work is forged on 2,000-pound to 6,000-pound machines. This adoption of the heavier hammers has also been brought about by a desire for greater output, as the larger the hammer the fewer blows required per forging. This is also easier on the hammer, as it is not worked to its fullest capacity, and the shock and strain on the various parts is less. In installing both board drop and steam drop, it is the prevailing practice to put in a larger hammer than might at first seem necessary.

In these days of scientific management the machine which will produce the maximum output at minimum maintenance cost is the tool that is in demand, and it is only by keeping in closest touch with working conditions that these conditions can be met.



CHAMBERSBURG
DROP HAMMERS
ARE
EFFICIENT, ECONOMICAL RELIABLE

¶ In the Board Drop Type, note the Front Rod which is practically straight. It is lifted onto shelf by means of the release lever, which rolls along in rack, without the usual slam and shock, thus obviating crystallization. Incline for knock-off is also so laid out that the impact on rod is very light. Front rod lever has patent safety stop which will absolutely prevent accidents and injury to operator while adjusting dies. Rolls and board clamps are carried in hooded eccentrics and are adjusted from floor. Ram when suspended is gripped so that it hangs free of both rolls, and the design is such that no matter how worn the board may be it will not drag through rolls when operating hammer. Frames are adjusted by large tension bolts, and construction is such that they can be removed by passing them out into die space without tearing down upper structure. Bulletin No. 60 completely illustrates and describes Hammer. Send for it.



¶ In the Steam Drop Hammer, the Frames are lipped at top by steel tie plate, and tied together by steel tie bars with distance pieces. At bottom the Frames are locked by the anvil on four sides to prevent shifting. Valve gear is of simplest and most durable type and gives operator perfect control at all times. All hammers are double-acting. Piston rings may be examined or replaced without dismantling hammer. Piston rod is made of 3½% nickel steel with head forged on solid. Ram and anvil cap are steel forgings. Send for Bulletin 46.

¶ Both types of Hammers are the result of long years' experience in Hammer building, and are built to jigs, thoroughly tested before shipment, and the design, material and workmanship absolutely guaranteed. They have proved the best in actual service.

Complete Drop Forge Equipment Our Specialty

Geared and Hydraulic Trimming Presses

CHAMBERSBURG ENGINEERING COMPANY
CHAMBERSBURG, PENNA., U.S.A.

The Edge of a Tool

THERE is probably no material which exhibits itself in so many different forms, or with such varying properties, as the wonderful substance which we call steel. Ordinarily defined as an alloy of iron with an iron carbide, containing from one-half to one and one-half per cent. of carbon, steel has come to mean a substance ranging from a soft, homogeneous material, ductile and tough, but utterly incapable of maintaining a cutting edge, to a product as hard or harder than glass and nearly as brittle. It is due to such a wide range of properties that the great usefulness of steel exists; some kind of steel may be found for almost every requirement, and it remains only to determine the requirements to lead to the manufacture of the product.

There are, however, certain requirements in engineering practice which include almost contradictory properties in the material. Thus, armour-plate must be very hard to resist penetration by projectiles, a condition readily met by a certain high-carbon content under proper heat treatment. It must also be very tough, otherwise it will fail by cracking, a condition demanding almost opposite constitution and treatment. To meet both requirements by one and the same material has long been a problem.

Again, the demands for tools for cutting metals have been enormously extended in late years by the discovery of certain alloy steels, which are capable of retaining the keenness of their cutting edges under speeds and temperatures formerly considered impracticable; but with these admirable properties there are included questions of strength and cost which materially affect their practical usefulness.

These are but examples of the combined and often contradictory requirements which the engineer and metallurgist are called upon to meet, and the limitations of a single material would seem to make such problems almost incapable of solution.

Fortunately, the immense variations in the character of the material which we call steel give what are really a number of different materials, and as these variations are due both to physical constitution and to local heat treatment, the modern metallurgist is solving the difficult problem of meeting contradictory requirements in one and the same piece.

In the production of cutting tools, for example, instead of incorporating in the entire mass the proportion of carbon and other elements necessary to the maintenance of a keen and enduring cutting edge it has been found practicable to infuse the necessary elements into the finished piece to the required depth without altering the constitution of the remainder of the piece. This means that a soft, cheap and easily workable material may be used in the first instance, and then, retaining all the toughness of the original, the carbon content and desired cutting qualities at the edge may be added afterwards, without impairing the strength and with but a small increase in cost. It is one of the marvels of steel that it may thus be caused to contain two identities in one, and to become hard and keen where hardness and keenness are essential, while remaining tough and workable in the remainder of the same piece.

Another curious and useful fact appears in this possibility of imparting local hardness to an otherwise soft and homogeneous piece. It is now established that hardened steel gradually changes its dimensions, probably by yielding to the internal stresses set up in the operation of hardening, so that gauges, for example, cannot be depended upon to remain constant if made of hardened steel throughout. Since the hardness is required only upon the surface, however, a soft, unchangeable steel may be used for the mass and the hardness infused to the moderate depth needed.

Why use bone for casehardening See what it contains??

LABORATORY OF C. L. CONSTANT
42 NEW STREET
NEW YORK CITY

CERTIFICATE OF ASSAY

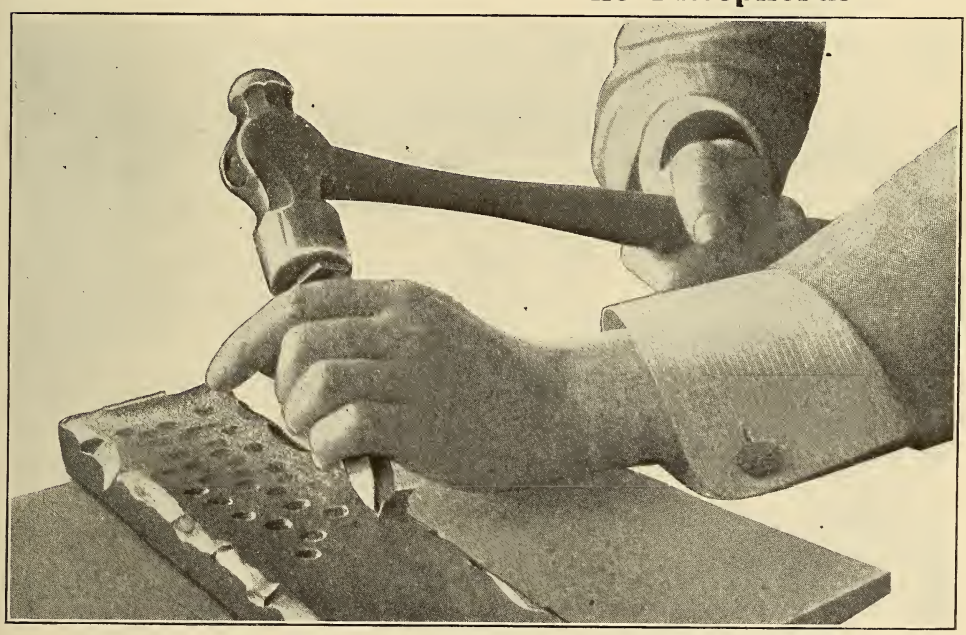
No. 42704 New York, March 23, 1912.

THE SAMPLE OF **"Case Hardening Bone"**
FROM Bought by us in open market for you
contains

Phosphoric Acid **27.16%**
Equivalent to
Phosphorus **14.20%**

To **The American Infusion Steel Process Co.**
Yours truly,
Signed by C. L. CONSTANT.

"STELPRO" Contains no bone therefore no Phosphorus



Ordinary Railroad Track Spike Infused With "Stelpro" Cutting Tool Steel Block.

Low Carbon Steel---plus "Stelpro" Equals "Better Than Tool Steel Results"

"Stelpro" a Scientific Hardening Mixture. Class "A" for Cutting Edges 20 cts. lb. Class "B" for wearing surfaces, 10 cts. per lb. In barrel lots.

Write for our New Illustrated Booklet and full information

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FINANCIAL AMERICA

"A thoroughly practical newspaper, a publication of, by and for business. It is one of the two most influential business periodicals in the Nation to-day."
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Prints daily a table showing relative worth compared with stock market prices, a complete analysis of the leading issues listed on the Stock Exchanges of the country, a concrete showing of actual conditions.

Thousands of pages have appeared in other publications in vain effort to reach facts here presented in form that the variest tyro can understand and appreciate.

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Information on industrial and other securities of value to investors and men of affairs.

OF THE

INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor

CHARLES EASTON, Financial Editor.

The Situation

WITH a view to securing "first-hand" information regarding business conditions, this magazine has had a special representative investigating the business situation in the most important Eastern, Southern and Western industrial centres. As a result of the information thus secured, we feel justified in repeating our prophecy that the business affairs of the country are destined to undergo a decided change for the better within the near future.

This somewhat optimistic statement is based upon the fact that all kinds and classes of business institutions have been actively engaged in "cleaning house," and, as a consequence, they have little or no surplus stock on hand, and are reduced to the necessity of placing "hurry-up orders" for the most commonplace materials. As an example, it has become a common practice for merchants to order by wire small quantities of goods to be shipped by express.

Railroads are placing orders for only such supplies as their immediate needs demand. One of the most prosperous Western roads, when asked why it was using cattle cars and ordinary box cars for the shipment of coal, replied that the road was pressing into service its present available equipment, regardless of character, rather than to go into the market for new. This same conservative policy is noticeable in many of the manufacturing enterprises; as, for instance, one of the largest cotton mills in New England stated that they were turning out no goods except on specific orders.

It must be acknowledged that, in a way, under-production is just as abnormal as over-production, the difference being that the former furnishes a most excellent basis upon which to build hopes of prosperity, whereas the latter always gives just cause for anticipating business depression. It is plain that the conduct of business along such narrow lines must, sooner or later, be terminated.

We do not believe that the revival of business will come in a sensational or flamboyant way; a gradual rise is preferable, because it is more substantial. The more carefully one analyzes the political situation as it pertains to commercial affairs, the less important it seems.

It must always be remembered that the American people, as a class, are of a very high order of intelligence, and capable of doing independent

thinking, and because of this fact they are not only more powerful than any one of our great political parties, or any man or set of men identified with same, but they are also more capable of passing upon any subject which is vital to our present form of government.

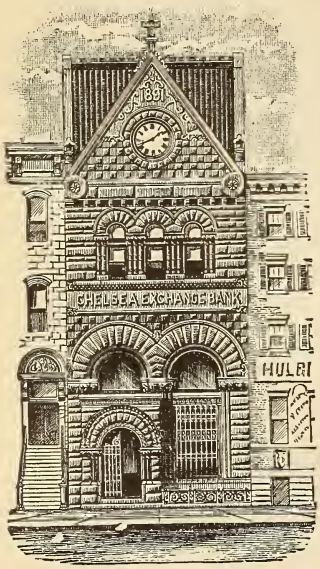
Many sincere people are depreciating the efforts of those who advocate a more direct government by the people, but we might as well recognize first as last that when a substantial number of American citizens earnestly and intelligently demand a change in our method of conducting governmental affairs they are very apt to get what they want, and it is safe to prophesy that the result will be brought about without endangering the stability of the nation.

Question—What do you think of Nevada-Utah Mines & Smelters Corporation?

Answer—This company is now in the throes of reorganization. Many plans are under consideration, but we are inclined to the belief that Trippe & Co., if allowed to continue as syndicate managers, will make a success of the undertaking.

During the past season in the Loop District of Chicago—the busiest portion of that city—there have been eleven sky-scrapers and other mammoth office buildings in simultaneous course of construction. The Chicago Pneumatic Tool Comapny, of Chicago, Ill., call attention, in a recent circular, that in all of them Chicago pneumatic tools have been used exclusively, these buildings being the Otis Building, the McCormick Building, the Monroe Bank Building, all built by Geo. A. Fuller Company; the Insurance Exchange Building, Thompson - Starrett Company, contractors; the Federal Building and

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

The Chelsea Exchange Bank

Located at

Thirty-fourth St. and Eighth Ave.

NEW YORK

Safe Deposit Vaults. Boxes $5.00 per year up

A Continually Growing Bank in a Continually Growing District

the Hamilton Club Building, Wells Brothers, contractors; the Telephone Building, the City Hall Square Building, the North American Building, the Mallers Building and the Rothschild Building. The Chicago Pneumatic Tool Company manufactures, among others, the folowing tools for mining, tunneling, quarrying and construction work: Chicago Giant rock drills, Chicago pneumatic air compressors, Boyer & Keller plug drills, Chicago Giant pile-driver, Boyer rivet buster and Little Giant ball-bearing air drills.

The Debenture Corporation of New York, in its Real Estate News letter, reports that there is increased activity in New York and suburban property. It anticipates a good spring business, and otherwise takes a hopeful view of the real estate market.

Question—What is your honest opinion of Texas farmland?

Answer—Judging from the information we have, no one would be taking the slightest chance in purchasing good Southwestern Texas farmland at fair prices, either for investment or active farming.

The Westinghouse Electric & Manufacturing Company shipped from East Pittsburg recently to the Pennsylvania Water Power Company, at McCall's Ferry, Pa., a 10,000 K. v. a., three-phase, 70,000/11,000-volt, 25-cycle transformer, to be used in connection with the transmission of electric energy to Baltimore.

This transformer is a duplicate of several others which were shipped some time ago, and an additional one is now being built, which will be used in the Baltimore sub-station.

Bank clearings for the week ending with March 21 show an increase of more than 16 per cent. over the corresponding week last year.

FREE REAL ESTATE MARKET LETTERS

ORIGINALLY sold for one-tenth cent an acre — recent sales at the rate of twenty-five million dollars an acre—such is the history of this wonderful Manhattan Island.

The marvelous growth of New York City and its suburbs, the remarkable increase in population (about 1,000 persons daily) with consequent enhancement of value are unprecedented in extent—unequaled in scope.

Billions of dollars are being made by realty experts and those associated with them. Perhaps you are one of the many who share these profits — if so, some of your money goes to make up the $10,000,000,000.00, now invested in New York Real Estate.

There is a medium through which you can keep informed regarding real estate and real estate securities.

We issue regularly a **Real Estate Market Letter** — an unusually interesting review of all important realty happenings in New York City and vicinity. Tells in a readable way, just the things which enable you to investigate before you invest—not afterwards. A reading of it should be to your decided advantage.

The mailing of the attached coupon entails no obligation on your part and will bring you, regularly, the Real Estate Market Letter.

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Please mail me, free of all charge, your Real Estate Market Letters.

NAME .....

MAILING ADDRESS .....

.....

Pine Orchard, Connecticut

is situated directly on Long Island Sound, 84 miles from New York City and 12 miles from New Haven.

This attractive resort, where you would like to live this summer, offers nearly all that any one could desire in the way of out-door sports and amusements, with its fishing, bathing and boating, also country club with lawn tennis courts, clock golf and a "sporty" golf course, splendid macadamized roads for automobiling and driving.

I live there myself during six months of the year, besides spending many pleasant week-ends during the winter. At the suggestion of some of my neighbors this advertisement is inserted for the purpose of interesting a few more congenial people, in order that desirable tenants may be found to occupy the few cottages unrented.

If a shore-front house surrounded by grass, trees, woods and country seems to appeal to you perhaps you will want to know more about these roomy houses. Everything that makes housekeeping easy in the way of city water, gas, electric lights, telephones, baths and open fire places is there.

Pine Orchard is accessible—yet retired. The grocer, butcher, milkman, baker, iceman and newsboy, make daily deliveries, but the usual fuss and conventional restrictions of summer resort life are absent.

If this sounds "too good to be true" call and see or write for photographic proof and judge for yourself.

EUGENE E. ADAMS
334 Fifth Avenue
New York City

Railway Wages and Railway Earnings

There were substantial increases in the wages of railway employees during the fiscal year 1911. Reports filed with the Interstate Commerce Commission show that the total compensation to the employees of railways over 500 miles long was $1,005,277,249. The total wage cost to the railways for the year was greater by $41,868,822 than it would have been at the rates of pay in effect during 1910, and greater by $69,297,678 than it would have been at the rates of pay in effect during 1909.

Notwithstanding an increase of 2,108 in the miles of railway operated, there were fewer employees on the payrolls June 30, 1911, than on June 30, 1910, by 31,037, yet the total compensation paid to employees during 1911 was greater than that paid during 1910 by $49,976,216. This is greater than the increase in the gross earnings of the railways by $22,595,121. The net revenues of the railways, which are what is left after paying operating expenses, fell off by $40,988,539 during this same period in which compensation increased nearly fifty million dollars.

These figures are summarized from Bulletin No. 28 of the Bureau of Railway Economics, which is based on official reports made by the railways to the Interstate Commerce Commission, and which exhibits in detail a comparison of the aggregate compensation to different classes of employees, the number of employees of different classes, and the relation to railway traffic for the fiscal years 1909, 1910 and 1911.

The Standard Steel Works Company, of Philadelphia, Pa., beg to announce the opening of a new branch office in the First National Bank building, Denver, Col. This will enable the consumers located in that vicinity to get in close and prompt touch with the company, whose services are always at their disposal, and who also extend an invitation to visit their office at any time.

The Hamburg-American Line makes an excellent showing for 1911. The company's net earnings are in excess of $10,000,000. It admits of a dividend of nine per cent., and leaves a substantial amount to be carried to surplus. Nothing could speak more eloquently for the character of its management than these splendid results.

Question—Do you still consider the purchase of Allis-Chalmers bonds advisable?

Answer—In a previous issue we advised the purchase of these bonds, since which time they have advanced about five points. However, we still regard them favourably.

The Kerr Turbine Company, Wellsville, N. Y., announce the appointment of the following new agents: St. Louis, Walter L. Flower, 312 South Eighth street, and New Orleans, C. E. Grevemberg, 1023 Maison Blanche building.

The S. K. F. Ball Bearing Company, 50 Church street, New York, has opened an office in Chicago to facilitate the handling of Western business. The new office will be in 1505 Heisen building, and in charge of Mr. C. A. Winn.

Orders aggregating $2,500,000 for 130 engines have been received by the Baldwin Locomotive Works in the last two weeks. The largest of these, for seventy engines, came from the Atchison, Topeka & Santa Fé Railroad. Ten locomotives will be built for the Western Maryland Railroad, five for the Chicago Great Western, six for the Norfolk & Western, thirty-three for the Harriman lines, and four for the Louisiana & Arkansas.

The Vulcan Engineering Sales Company has been organized and incorporated, with offices in the Fisher Building, Chicago, and 30 Church street, New York. The company controls the entire product, and will handle all sales of the Hanna Engineering Works, of Chicago; Mumford Molding Machine Company, of Plainfield, N. J., and O. M. S. Company, of New York. Further factory arrangements are under way, and the Vulcan Company will own and manufacture a number of railway special tools and equipment for shop and maintenance departments.

The officers are: H. K. Gilbert, president, formerly vice-president of the Buda Company, and P. W. Gates, secretary and treasurer, now president of the Hanna Engineering Works, formerly president of the Gates Iron Works.

E. H. Mumford, now vice-president and general manager of the Mumford Holding Machine Company, will continue in the same position and duties as heretofore, and William L. Laib, vice-president and secretary of the Hanna Engineering Works, will continue in his present position with that company.

Question—What do you think of the possibilities of an immediate rise in the stock market?

Answer—This is a hard question. However, taking a considerable number of the stocks which form the backbone of the general list, recent prices show a substantial advance. It is conceded that the old short interests have been driven to cover during the past month, but apparently there is a new element stubbornly opposing the recent rise. There is no good reason for a decline in prices.

The Harrisburg Manufacturing & Boiler Company announces that it has placed the sale of the well-known Star Water Tube Boiler Company in the hands of the Harrisburg Star Boiler Company, with offices at No. 1 Madison avenue, New York, N. Y.

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER
ALBANY, N. Y. Industrial Agent

If You Use the Wires

YOU NEED

The Western Union Telegraphic Code

For General and Technical Messages

It Will Reduce Your Bills

The volume will be submitted to responsible firms upon request.

APPLY TO

International Cable Directory Co.
59 Pearl Street, New York
LONDON PARIS HAMBURG

Board of Patent Appeals

The bill to amend the statutes relating to patents (H. R. 7609) provides that the Commissioner of Patents, the First Commissioner of Patents, the Assistant Commissioner of Patents and the examiners-in-chief shall constitute a Board of Appeals, any three of whom, by designation of the commissioner, shall constitute a quorum, whose duty it shall be, upon written application of the appellant, to revise and determine upon the validity of adverse decisions of examiners upon application for patents and for reissue of patents and in interference cases. The members of the Board of Appeals shall not be engaged in any other business, avocation or employment.

If any party is dissatisfied with the decision of the Board of Appeals he may appeal to the Court of Appeals of the District of Columbia.

The following are to be the rates for patent fees:

On filing each original application for a patent, except in design cases, $15.

On issuing each original patent, except in design cases, $20.

In design cases: For three years and six months, $10; for seven years, $15; for fourteen years, $30.

On every application for the reissue of a patent, $30.

On filing each disclaim, $10.

On an appeal for the first time to the Board of Appeals in ex parte cases, $10.

On an appeal for the first time in an interference, $20.

For certified copies of patents and other papers, including certified printed copies, 10 cents per hundred words.

For recording assignments or other papers, 300 words or under, $1; 300 to 1,000 words, $2; each additional 1,000 words or fraction thereof, $1.

Certified copies of drawings and specifications, 25 cents additional to present rates for uncertified copies.

For copies of drawings, reasonable cost of making them.

The Efficiency Society

(Concluded from page 63.)

zation Applied to an Individual Manufacturing Establishment. Henry R. Towne, president Yale & Towne Manufacturing Company.

The Organization of an Aggregation of Manufacturing Establishments. C. U. Carpenter, ex-president Herring-Hall-Marvin Safe Company.

The Organization of a Whole Industry. Dr. Wm. Jay Schieffelin, Schieffelin & Co.

The evening session, which took the form of after-dinner addresses, was a symposium on Efficiency in Government Methods, by Government Officials, as follows:

A letter of felicitation from the President of the United States, who was prevented from attending by a previous engagement in Boston.

The Need for Increased Efficiency. Hon. John A. Dix, Governor of New York.

Efficient Methods in Legal Procedure and Practice. Hon. Wm. J. Gaynor, Mayor of the city of New York.

The Reorganization of a Department of the Government. Hon G. Von L. Meyer, Secretary of the Navy.

The Government's Interest in Business Efficiency. Hon Herbert Knox Smith, Commissioner of Corporations, Bureau of Commerce and Labor.

Efficiency in Public Management. Dr. F. A. Cleveland, director President's Commission on Efficiency and Economy.

The morning and afternoon sessions of Tuesday were devoted to a symposium on management, as follows:

The Initial Financing of an Enterprise. E. R. Chapman, president Hudson Trust Company.

The Administrative Departments. Melville W. Mix, president Dodge Manufacturing Company.

Advertising. W. H. Ingersoll, of R. H. Ingersoll & Co.

The Sales Department. W. H. Cottingham, president Sherwin-Williams Company.

Purchasing. Elihu C. Church, purchasing agent Department Water Supply, Gas and Electricity, New York City.

The Production Department. John Calder, manager Remington Typewriter Works.

The Record and Cost Department. S. S. Wheeler, president Crocker-Wheeler Company.

The Human Element. Dr. Luther H. Gulick, Russell Sage Foundation.

Industrial Education. M. W. Alexander, superintendent apprentices, General Electric Company.

Every paper was presented by a business executive who was known to be an authority on the subject he had in hand. They were all of great value, and the latter was increased by the discussion which accompanied their presentation. The field of industry was well covered by the topics presented. A business man or manufacturer will find each of the departments of his enterprise thoroughly treated by an adept. These papers will be printed for distribution separately and together in the first volume of the Transactions.

The first meeting of the Efficiency Society was a complete success. The headquarters will remain temporarily in the Metropolitan Building, 1 Madison avenue, with Mr. H. F. J. Porter continuing to act as secretary.

Need for More Railways in Alaska

At the close of 1911 there were 465 miles of railways in the Territory, compared with 371 miles in 1910. This mileage is distributed between nine different railways from 5 to 196 miles in length. The existing railways emphasize the need of additional transportation facilities. The most urgent need is for a railway to connect an open port on the Pacific with the Yukon basin. Until such a line is built only the richest placers of the interior and only the most favourably located lodes can be profitably exploited.

Westinghouse Electric & Manufacturing Company Receives Large Order from Pacific Coast

The city of Los Angeles six years ago voted an issue of $24,000,000 in bonds to pay for what they considered the finest water supply in the world.

The aqueduct, which is 250 miles long, will bring an amount of water sufficient to supply a city of 2,000,000 inhabitants from Owens Lake, which has an area of 75 square miles at an elevation of 3,812 feet in a group of 23 peaks, all of which are over 13,500 feet high. The highest one, Mt. Whitney, is 14,500 feet high. These mountains are snow-covered the year around.

Owens Lake, which receives the drainage of 2,800 square miles, is near the Nevada line, 50 miles east of the Yosemite National Park.

The first 20 miles of the aqueduct is an open earth canal, the next 39 miles is an open concrete conduit, laid on the mountain sides, and follows their contour like a road. For 28 miles the conduit rests in ditches carved from the rocky walls, and for an equal distance is sustained by artificial causeways of rocks. It next passes 150 miles through the Mojave Desert on the edge of Death Valley, the most desolate and forbidding spot in the United States. Finally, it passes under the Sierra Madre range of mountains and emerges into Los Angeles Valley, 1,000 feet above the city, which is 20 miles away.

One of the projects to be operated in connection with this undertaking is the operation of a large hydro-electric power system. Electric energy will be transmitted to Los Angeles and sold by the city.

Bonds for the erection of the plant amounting to $357,367 were recently authorized by the city, and the contract for the electrical equipment of the power house and sub-station has just been awarded to a Pittsburg firm, the Westinghouse Electric & Manufacturing Company.

This contract calls for three 13,500 horse-power generators, ten 4,200 horse-power transformers for raising the generator voltage from 6,600 to 60,000 volts, at which it will be transmitted to a sub-station near the city, and nine 6,700 horse-power transformers for reducing the transmission voltage at the end of the line.

These generators are of the latest water-wheel type developed by the Westinghouse Company, and are of unusually large size.

The transformers are of the oil-insulated, water-cooled type especially adapted for this class of work.

The contract imposes a penalty of several hundred dollars a day for failure to meet the delivery dates agreed upon. Shipment will begin the 1st of August and be completed the first part of November.

It will furnish work for a good portion of the East Pittsburg shops for some months.

The main power plant is at San Francisco and the sub-station at Los Angeles, a distance of 47 miles.

Do You Occasionally Require A Representative in New York?

MOST CONCERNS DO

though their requirements may be at irregular intervals, or their demand may need part time of an individual only.

If Yours Is Such A Concern

would you not appreciate being able to promptly, by wire, 'phone or letter, have an experienced and reliable man on the spot? To obtain and pay for such services on his part as your actual demand requires

You Can Arrange For Such A Man At Reasonable Expense

A specialty of such representation is made by the undersigned who will give personal and prompt attention to all such business, and will send full information as to experience, terms and references on request.

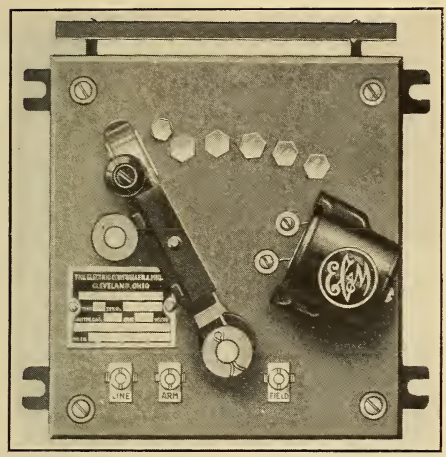
Why Not Write Him Today You May Need Him Tomorrow

H. C. HORTON
50 Pine St., New York

A NEW LINE OF MOTOR STARTING RHEOSTATS

THERE has recently been placed on the market by the Electric Controller & Manufacturing Company, of Cleveland, Ohio, a new line of starting rheostats for series, shunt or compound wound, direct-connected motors, for which the following important advantages are claimed:

The highest grade of Monson slate is used, having beveled edges and oil finish.



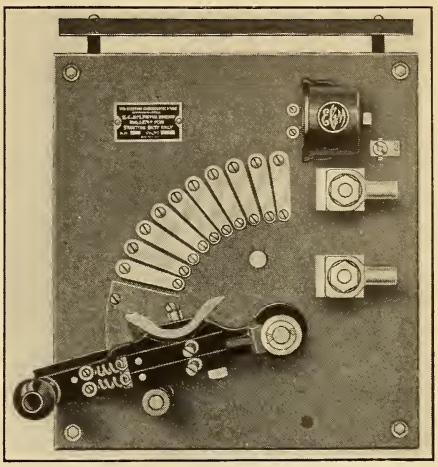
MOTOR STARTER RHEOSTAT. ELECTRIC CONTROLLER & MANUFACTURING COMPANY

On all sizes the contacts are removable from the front of the rheostat without disassembling or interfering in any way with the wiring or resistance.

The retaining magnet is iron-clad, thus being protected from mechanical injury.

The resistance wire, the capacity of which is liberally proportioned, is wound on asbestos-covered metallic tubes, through which a draft of air flows. While this draft of air very efficiently conveys the heat away from the resistance, yet it does not at any time touch the hot resistance wire, the obvious result being unusual freedom from oxidization of the resistance wire.

The E. C. & M. motor starting rheostats are regularly furnished in sizes from ¼ horse-power to 35 horse-power, 110 volts, and from ¼ horse-power to 50 horse-power, 220 and 550 volts.



MOTOR STARTER RHEOSTAT, CUT NO. 2

Starters similar to Cut No. 1 will be supplied for motors up to and including 7½ horse-power, 110 volts; 15 horse-power, 220 volts, and 20 horse-power, 550 volts. For larger sizes the starter will be similar to Cut No. 2.

A New Chain Graphite

The Joseph Dixon Crucible Company, of Jersey City, has just put on the market a new chain graphite, especially intended for lubricating the chains of motor trucks and pleasure cars.

This preparation is put up in sticks, cylindrical shape, 2 inches by 8 inches, encased in a neat cardboard carton, and weighing about one pound each. It is made of the same material as the Dixon Bicycle Stick Graphite, with which every bicycle owner is familiar.

It is by far the most convenient chain lubricant on the market, for a bar may be carried on the car ready for use at any time. To apply, it is simply necessary to rub the bar against the sprocket side of the chain. The "big stick" makes it easy to keep automobile driving chains in first-class condition. Unlike oils and greases, it will not collect dust and dirt.

Wainwright Apparatus from the Practical View

Under the above title there has been issued by the Alberger Condenser Company, of New York, a very interesting bulletin descriptive of the Wainwright corrugated tube, which is meeting with such great success in locations where feed water is bad. Water, in its zigzag course through this corrugated tube, is directed against its walls, thus providing a positive means for preventing the accumulations of scale and insoluble impurities on the heating surface. The Wainwright spiral-flow tube, which is designed for use for heaters where service is intermittent, the Wainwright feed-water heater, the Wainwright domestic water heater, the Wainwright water heaters for industrial service, the Wainwright gravity heating system, the Wainwright forced circulation heating system heater, the Alberger circulating pump, the Wainwright improved expansion joint, the Wainwright turbine expansion joint and the Wainwright anchors and guides are all described in this new catalogue. Other publications of the Alberger Condenser Company are "Condensing Equipment," "Vacuum Pumps," "Cooling Towers," "Improved Cooling Tower," "Centrifugal Pumping Machinery," "Feed-Water Heaters" and "Expansion Joints," any of which may be obtained by addressing them at 140 Cedar street, New York, N. Y.

Value of the Aeroplane—Events in Tripoli Show Their Practical and Startling Army Results

Events in Tripoli, says the New York *Times,* have given a startling, practical demonstration of the value of the aeroplane in time of war. In the face of this menacing assertion it is stated that the United States and British armies are far weaker, as far as aeronautics are concerned, than that of every other first class, and many a second class, Power.

The aeroplane, and to a lesser extent the dirigible, have profoundly affected modern methods of warfare, and the science of tactics and strategy in particular. The chief function of aircraft is reconnoitring, scouting and observation. Carried out by cavalry, scouting is a slow, wasteful and most uncertain process; its results, moreover, are slight and always incomplete.

But an aeroplane can cover the whole extent of a battlefield, working far back over the enemy's rear and lines of communication and scour the surrounding country in a few hours, and a trained observer will bring back accurate information regarding the disposition and movements of the enemy's troops. With the aid of photography, he can bring documentary evidence to confirm his observations, and by means of wireless telegraphy he can keep in constant touch with headquarters.

Wireless messages have been transmitted from aeroplanes over a distance of 30 miles. Not a movement of troops, not a masked battery or hidden emplacement, escapes the aeronaut. He can observe the effect of gunfire and constantly direct it. He can be made the means for establishing rapid and certain communication across hostile or broken country, impassable by every other method. The vast complexities of modern battle are spread out below him, to be read at a glance of his all-comprehending eye. He can spot a submerged submarine and give notice of hostile ships hours before it would be known by ordinary means. And all this may be accomplished in absolute safety; for an aeroplane is practically out of range at an altitude of 4,000 feet, and at that height is also out of range of heavy guns incapable of high-angle fire.

THE UNIVERSAL TELEGRAPH CODE

By A. Nachmann

THE gradual development of the transmission of messages from the post chaise, stage mail coach, and railroad, to the overland telegraph has transformed the conduct of business. When electric communication was still further extended by the completion of the submarine cable, at first across the Atlantic and then to other parts of the world, the idea of reducing the cost of the service by the use of code systems, in which entire sentences should be represented by single words, naturally followed. Such codes were at first private and personal, but the demands of the business world required, first, the preparation of a general code of such universal character that it would serve the purposes of all kinds of business, and second, such a distribution of the code that it would be in the hands of a world-wide number of known users.

These principles, if carried out, would enable any business man to communicate by code message to any subscriber in any part of the world without previous arrangement.

The result was an enterprising group of men, possessing the necessary requisites, decided to undertake the venture. An expert code compiler was engaged, supplied with a competent staff and the work began.

After months of labour a code was evolved embracing some 175,000 code words and phrases, and then began the enormous task of introducing the volume throughout the world. Travelers were engaged and agencies established. More important than these, however, were the arrangements made with various telegraph systems to place the volume in their offices, in order that travelers might be enabled to cipher or decipher messages emanating from or addressed to their firms or homes. This, too, was finally accomplished, and the first steps were made in the establishment of a "Universal" Code System.

The advantages were quickly realized, and the effort met with a most favourable response.

After a few years' experience with the code and list of subscribers in one volume, it was found advisable to separate the two portions, and while the code proved equal to all demands, the register has been gradually improved, so that at the present time it is arranged in two divisions—the first arranged by continents, states and cities, under which the names appear alphabetically, and the second arranged by classified business headings, these being printed and indexed in English, French, German and Spanish.

The general excellence of the Western Union Telegraph Code, as the Universal Code is named, has caused its use to become world-wide, and an indication of this fact appears in the official order of the Department of State at Washington directing that it be placed in the embassies, legations and consulates of the United States for the use of Americans abroad and for the promotion of commercial relations with the United States by residents of other countries. The Universal Code may also be procured in practically every hotel of importance on all five continents, on steamships, in chambers of commerce, and in many public institutions.

In the 1912 edition of the International Cable Register there is given an alphabetical list of cable addresses, each one preceded by a four-letter code word charged for as one word; also, a list of cities in which are located stations of the various telegraph and cable systems, thus enabling the messages to be made up in the most effective manner.

The International Cable Directory Company is prepared to submit samples of the various publications to reputable firms for examination.

The Powell Engine Corporation, of Brooklyn, N. Y., announces that it is putting on the market a new motor truck of one and one-half tons capacity, the chassis being offered for sale at $2,250.

This truck is equipped with a four-cylinder vertical engine, with cylinders of 3⅞ inches bore and 4½ inches stroke, capable of developing 24 horse-power, according to the A. L. A. M. rating. The weight of the chassis is 3,800 pounds, the over-all length is 174 inches, and the loading space 138 inches long and of optional width. According to the specifications furnished by the manufacturers, this truck is a thoroughly equipped piece of machinery, and the fact that these well-known builders of marine and automobile engines have entered the motor truck field is evidence of the healthy and effective growth of the industry.

Phosphate Lands Withdrawn from Entry

During January 214,749 acres of land in the State of Idaho believed to be underlain by phosphate rock were withdrawn on recommendation of the United States Geological Survey. This makes a total outstanding withdrawal in Idaho of 1,167,137 acres of phosphate land. In Wyoming 1,266,668 acres are now withdrawn as phosphate land, in Utah 107,745 acres, in Montana 33,950 acres, and in Florida 35,640 acres, a total of 2,611,140 acres. Partial detailed surveys of these areas made by Survey geologists show a very large quantity of this important fertilizer, the value ranging up into the billions of dollars. The Director of the Survey, in his latest annual report, calls attention to the need of the enactment of a law that will permit development of this resource, which is coming more and more into use as an agricultural soil stimulant. The United States is believed to have the greatest phosphate deposits in the world.

-the safest pen for Field work is

The SECURITY Guaranteed Fountain Pen

non-leakable

No. 3 S.Y. made with a short, heavy cap that screws down tightly over the section. 14kt. Gold Nib. Prevents any leak or overflow of ink while the pen is carried in vest or trouser pocket or traveling bag, or while lying flat on desk. They are the safest and most convenient pen made, and hold plenty of ink for ten days' use.

Sent postpaid for ten days' trial— money back if you want it. $1.50

-the time saving Draughting Stylo

No. 33 This pen has a smooth point and patent needle, insuring a ready and easy flow of ink. Writes ten days without refilling. This Stylo Pen is made of the best quality pure Rubber in red or black and is manufactured in the best possible manner. This pen can be safely carried in the vest pocket or traveling bag, as it is an absolutely non-leakable Stylo Pen, and is always ready to write. "Buy a red one for red ink and a black one for black ink." $1.00 postpaid

DIAMOND POINT PEN CO., 39 to 47 West 19th St., New York

PERSONALS

Mr. Charles E. Downton, representing the Westinghouse Electric & Manufacturing Company, recently presented to the members of the senior class of the College of Engineering of the University of Illinois the advantages offered by his company in the matter of positions for technical graduates.

Mr. C. C. Owens has recently been placed in charge of the Detroit district sales office of the Westinghouse Electric & Manufacturing Company, with the title of District Manager.

Mr. Owens was born in 1877 near Annapolis, Md., and graduated from Columbian University, Washington, D. C., with the degree of Bachelor of Science in electrical engineering. He entered the employ of the Westinghouse Electric & Manufacturing Company in 1896, taking the apprenticeship course for three years, after which he spent four years in the engineering department, specializing on switchboards and controllers.

For the last eight years he has been connected with the New York sales office.

A Recognition of Industrial Efficiency

On Saturday afternoon, March 16, there was presented to Mr. George H. Graves, treasurer, and Mr. George T. Coppins, secretary, of the Walworth Manufacturing Company, twin loving cups.

There were twenty subscribers to the fund which purchased these cups, the subscribers being, with two exceptions, men who had served immediately under the direction of Messrs. Graves and Coppins for a period exceeding twenty years, the longest covering a period of fifty-seven and one-half years. It is doubtful if this record can be equaled or even approached. The incident is all the more remarkable in that these men are still in active service and doing good work.

Rear-Admiral George Wallace Melville

The death of Rear-Admiral George Wallace Melville, which took place at his home in Philadelphia on March 17, brings to a close a career of eminence in engineering and exploration which was remarkable in many ways. To the engineer, he will be remembered as Engineer-in-Chief of the United States Navy from 1887 to 1903, the period in which the modern American Navy was developed, and his impress as an engineer appears in practically all the machinery in its present use.

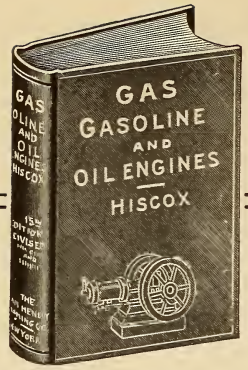
To the general public he is known as the brave Arctic explorer who faced death in the Lena Delta to bring back to civilization the remains of De Long and his companions, and who rescued the Greely Expedition.

To all his friends he was the bluff sailor, the ingenious inventor, the masterful administrator, and the beloved companion.

A sympathetic biographical sketch of Admiral Melville, with portrait, prepared by Mr. Walter M. McFarland, was published in the issue of this magazine for September, 1903.

Professor Henry W. Spangler

The death of Professor Henry W. Spangler, of the University of Pennsylvania, brings to a close a career identified with engineering education in its most effective form. During the past twenty years he has made the department of mechanical engineering at the University of Pennsylvania a notable school, from which men have been graduated into the ranks of the profession and developed into eminence and success, and he leaves as a memorial to his work the organization, equipment and methods which will, doubtless, long continue.



GAS, GASOLINE AND OIL ENGINES

By GARDNER D. HISCOX, M.E.

Just issued. Twentieth edition. The book treats on the theory of Gas, Gasoline and Oil Engines as designed and manufactured in the United States. Explosive motors, stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric Ignition by Induction Coil and Jump Sparks are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. 450 octavo pages, fully illustrated by 351 engravings. Price.....**$2.50**

MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT

By OSCAR E. PERRIGO, M.E.

A work of 400 pages, dealing with every problem connected with the building and conducting of a modern factory or shop. The subject-matter embraces the designing of the buildings, the installing of machinery, etc., and the turning out of work. For convenience the book is divided into three parts: The first part deals with the construction and the providing of power, heating and ventilating and lighting; the second part takes up the equipment, both mechanical and administrative, and the third part pertains to management, introducing a simple and efficient time and cost system. Price.....**$5.00**

HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL

By JOSEPH V. WOODWORTH

A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price.....**$2.50**

PATTERN MAKING

By F. W. BARROWS, Practical Pattern Maker

This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price.....**$2.00**

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128 NASSAU STREET, NEW YORK, U. S. A.

Transmission Machinery

C-12, the new catalogue of the Dodge Manufacturing Company, is now being distributed. It has 413 pages, is beautifully printed and illustrated, and describes and lists in complete form the goods the Dodge people make at Mishawaka, Ind.

As an introduction, the first pages are devoted to interior views of Dodge foundries, machine shops, power plant and branch houses; then follow tables for laying out shafting, horse-power of steel shafting, dimensions, etc. Every product of the company, a complete line of power transmission machinery and appliances, elevating and conveying equipment, rope driving system and water softener apparatus is completely described and listed. Considerable space is devoted to the Dodge friction clutch as an accident prevention device. Concluding pages give a little history of the transmission of power by Manila rope, with illustrations of a number of striking installations, heavy engineering work and the Eureka water softener and purifier.

The publication of this book adds another year to the life of the company. Established in 1878 by Wallace H. Dodge, it has been an important factor in the industrial life of America. First incorporated under the laws of Indiana with a capital stock of $50,000, this has passed over the million mark. Since its inception the Dodge Manufacturing Company has never had an unprofitable year. Considerably more than $2,500,000 has been earned for shareholders, and of this more than $2,000,000 has been added by reinvestment to the company's resources.

The business got its start through the invention by Mr. Dodge of the split wood pulley with interchangeable bushings, a revolution in the pulley art. At that time the plant occupied only a few acres of ground in Mishawaka. To-day there are sixty-three acres of ground space and over twenty-one acres of floor space.

This great factory is equipped with every facility required in the economic and efficient operation of various de-

partments, and this is supplemented by a vast selling organization, taking in branch houses at New York, Boston, Pittsburg, Philadelphia, Cincinnati, Minneapolis, Chicago, St. Louis and Atlanta, and stock-carrying agents in every power-using community. The company enjoys a world-wide reputation, both as to products and management.

Hot Blast Heating and Ventilating Outfits

In a new 94-page book bearing the title "Heating and Ventilating" there has been brought together the information required for the designing and proportioning of hot blast outfits for heating, ventilating, drying, etc. The book contains some two or three dozen tables of temperatures required in rooms for various purposes; heat transmission through building materials; heat given off by occupants and by lights; standard sizes of hot-blast heaters; frictional resistance of air washers; relative humidities; humidities and temperatures throughout the United States; amounts of air required for ventilation; equivalent air pressures, velocities and horse-powers; total weight of air at various barometers and temperatures; pressure and power consumed in friction; speed, capacity and power of steel-plate fans; friction of air through hot-blast coils, etc. The text takes up not only the usual details relating to the construction of fans, heaters and heating and ventilating systems, but also the calculation and designing of piping systems, giving for the latter two methods differing somewhat—viz., that used in the office of the supervising architects at Washington and that proposed by Riltschel and covering the resistance of sheet-iron pipes and of angles, bends, branches, grills or registers, etc. There is also a chapter on the loss of head of air flowing through orifices and equivalent orifices, in which is presented a method of combining the resistances of ducts in parallel and series connections analogous to the Ohm's and Kirchoff's laws for electrical circuits. Another chapter gives the result of an extensive series of tests upon Green's positive-flow steam heating coils, by means of which heaters of suitable sizes may be selected for any given duty. The general illustrations of the book include not only views of buildings equipped with heating and ventilating apparatus built by the Green Fuel Economizer Company, but also detailed plans, elevations and "ghost" views showing the actual arrangement of the fans, heaters, piping, outlets, etc. Copies of this book will be sent to architects, heating and ventilating engineers and others concerned with the purchase, design or operation of heating plants on request to the Green Fuel Economizer Company, Matteawan, N. Y., and mention of CASSIER'S MAGAZINE.

Condensite for Plastic Moulding

Condensite is of the class of substance known in chemistry as "phenolic condensation products," and is produced by a reaction between phenol and formaldehyde. This reaction has been known for years, but until the advent of condensite no "phenolic condensation products" had been free from water or the impurities incident to manufacture or of variations in quality that seriously interfered with their use. In the manufacture of condensite a radical departure from all previous methods is employed, as is explained in this catalogue.

This product is used for electric insulation, phonograph records, printing plates, valve discs, buttons, handles, billiard and pool balls, instruments of precision, etc., and is very easy to mould, as it does not adhere to the mould, thus avoiding all oiling of moulds.

The book is issued by the Condensite Company, Glen Ridge, N. J., and contains much interesting data. It can be obtained by addressing the company and mentioning CASSIER'S MAGAZINE.

THE LATEST CATALOGUES

"Stelpro"

An instructive catalogue of convenient size, clear text and type and fine illustrations has just been issued by the American Infusion Steel Process Co., 60 Broadway, New York. The work describes the numerous uses for which this new product is so well adapted, and for which it is meeting with such great success. "Stelpro" is a powder containing certain valuable ingredients, which, when heated in contact with low-carbon Bessemer and open-hearth steels—steels costing from 1½ cents to 6 cents a pound — converts these low-grade steels, at their working surfaces, into a superior quality of high-carbon "tool" steel; and in the case of a special type "N" (6-cent) open-hearth steel produces a tool which, in many cases, equals the performance of high-speed steels. To users of drills, cutters, reamers, taps, gears, pinions, milling cutters, etc., and to manufacturers in general who require either small or large steel parts, etc., this book contains a great deal of valuable information.

The book is divided into the following headings: American Infusion Steel Process Company New Plant; "Stelpro"—A description of this new product; How to use "Stelpro"; cleaning, containers, packing, time, penetration, quenching, heat treatment, etc., and contains photographic reproductions of reports, etc., from the Bureau of Ordnance, Navy Department, speaking in flattering terms of the results obtained by the use of this process.

A copy of the catalogue may be obtained by addressing the company and mentioning CASSIER'S MAGAZINE.

"Synchronous Motors for Power Factor Correction" is the title of Special Publication R. L. 57, issued by the Railway and Lighting Department of the Westinghouse Electric & Manufacturing Company, East Pittsburg, Pa. This booklet, which has an art cover, contains some of the most valuable, common-sense data on the phenomena of power factor and on the bad effects of low power factor and its power factor correction with synchronous motors that has ever been printed. That it is being distributed without charge and apparently at much expense, furnishes an illustration of the policy of some of the present-day manufacturing companies of spending considerable money to educate the possible buyer as to the selection and application of equipment that is not generally understood.

Besides a discussion of power factor and its correction by Nicholas Stahl, the publication gives much specific data on and illustrates many synchronous motor installations made for improving low power factors.

Curves and diagrams are given whereby one can determine, with a few simple calculations, the capacity of a synchronous motor necessary to correct a given load from and to given power factors. Directions and diagrams are given for solving by inspection the other problems that arise in connection with power factor phenomena. The feature of the booklet that will be appreciated by practical engineers is the simplicity of the treatment of the many examples illustrating the use of the data and curves. This book should be in the hands of every man that has to do with alternating current.

Automatic Cellar Drainer

The Penberthy Injector Company, Detroit, Mich., have recently issued a descriptive pamphlet of their automatic cellar drainer, which is particularly adapted for use in pits, sumps, cellars, tanks, settling basins, or wherever it is desired to keep water and other liquids from going above a certain level. A copy may be obtained by addressing them.

Hammer Drills

Ingersoll-Rand Company, 11 Broadway, New York City. Bulletin 4111, 16 pages, 6 x 9, descriptive of Type "BC" Butterfly Hammer Drills. These drills are equipped with telescope feed, and can also be furnished with dust allayers, which are strongly advocated as a safeguard to the health of the miners. Water can be sucked up six or eight feet from a pail or bucket, no tank or pressure line being necessary. This makes the use of the water spray possible under all conditions, no matter how small the working or how far away from the source of water supply.

The Butterfly valve consists of two wings and a central stem on which it oscillates. One wing controls the supply to each end of the cylinder, the other wing controlling the exhaust. As the two wings are of the same area, the pressure holding the supply wing on its seat is equaled by the pressure, tending to force the exhaust wing off its seat, thus making a balanced valve which requires very little pressure to shift it. The valve closes the ports by advancing to the seat, not by sliding on the seat, thus making a better fit the longer it runs. All exhaust is at one point, and directed back parallel to the feed cylinder, minimizing the tendency to scatter dust. This positiveness and simplicity of valve action is a very desirable feature.

Catalogue shows sectional views of machine and also several cuts of machine at work underground, together with list of duplicate parts.

"Hammer Drills": A 12-page, 6 x 9, pamphlet Form No. 4016, issued by Ingersoll-Rand Company, 11 Broadway, New York City, descriptive of the "MC-22" Telescope Feed Hammer Drill. This drill is of the "valveless" type, in which the piston itself performs the valve functions by covering or uncovering ports, which control its forward-and-back movement. This tool is intended for stoping, raising, and, to a limited extent, drifting. It is not recommended for steady work in holes at less than 20 degrees from the horizontal, because of the difficulty of cleaning such holes. The telescope feed of the "MC-22" is that designated by the company as the "reversed feed," in which the inner, or piston, tube is attached to the drill, and the outer, or cylinder, tube runs out under pressure. The advantage of this arrangement is that the hose is stationary, not turning with the drill; and the tool may be used on a tripod or column by clamping the outer feed cylinder to the mounting. Catalogue shows several views of machine in section, and also list of duplicate parts.

"The Application of Electricity to Marine Service" is the title of Bulletin No. 4926, just issued by the General Electric Company. This publication is printed in colors, describes the various pieces of apparatus and supplies manufactured by this company for marine use, and contains data of general interest to motor-boat owners. Among these data will be found reproductions, in colors, of the flags of the principal yacht clubs throughout the country.

Feeder Voltage Regulators

The General Electric Company has just issued a bulletin, No. 4927, which describes the manufacture of that Company's feeder voltage regulators. It illustrates the various processes of the manufacture and shows the facilities possessed by this company at its Pittsfield works for the manufacture of this type of apparatus. The publication will be found of great interest to electrical men generally.

The

Santo Twin Sweeper

(Electric)

Is the new Suction Sweeper just added to our line of Santo Vacuum Cleaners.

It embodies a number of new ideas and improvements of our own, making it more efficient than any other suction sweeper now on the market.
We manufacture the following types of Portable and Stationary Vacuum Cleaners:—

THE SANTO VACUUM CLEANER
(Portable Electric)

THE SANTO TWIN SWEEPER
(Electric)

THE SANTO-DUPLEX
(Stationary Plant)

Santo Vacuum Cleaners are manufactured under our own patents and licensed under basic ones.

Send for Booklets describing our various types of Cleaners

Keller Mfg. Co.
Dept. C **Phila. Pa.**

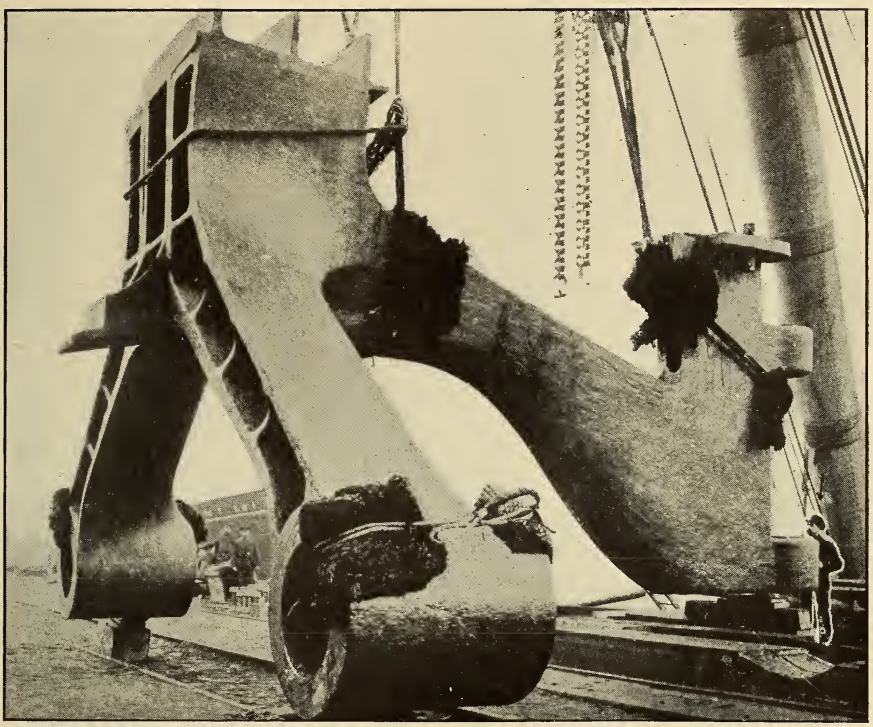
Commercial Cars

"The Heart of the 'Little Giant' Model D Commercial Car" is the title of a most unique catalogue just issued by the Chicago Pneumatic Tool Co., Fisher Building, Chicago, which shows in a novel manner different styles of bodies mounted on the "Little Giant" chassis, and gives information concerning details of construction. This company has also recently issued a larger and more complete catalogue describing this commercial car. Both these publications will prove of interest to users of commercial cars, and may be obtained by addressing them.

Tanks

W. E. Caldwell Company, Inc., Louisville, Ky., steel and wood tanks and towers, the keynote of this catalogue being "Steel Tanks to the Front and Wood Tanks to the Rear." In making this statement, however, this company does not mean that they are going to give any less attention to the manufacture of wood tanks, or that they have lost any ground in that line, but that they have built steel tanks for years and that their business in them is continually increasing. Their new and very handsome 100-page catalogue is profusely illustrated, and gives full description of the Caldwell tanks and towers, which have long been so favourably known. The list of some of the cities and towns that have installed Caldwell tanks and towers which is given in their new catalogue indicates the high regard in which they are held. A copy of this new catalogue is well worth having, and can be obtained by addressing them and mentioning CASSIER'S MAGAZINE.

D. Van Nostrand, the well-known scientific publishers, announce the removal of their offices and salesrooms to 25 Park place, between Broadway and Church streets, New York, where they have secured larger quarters, made necessary by their continuously growing business.

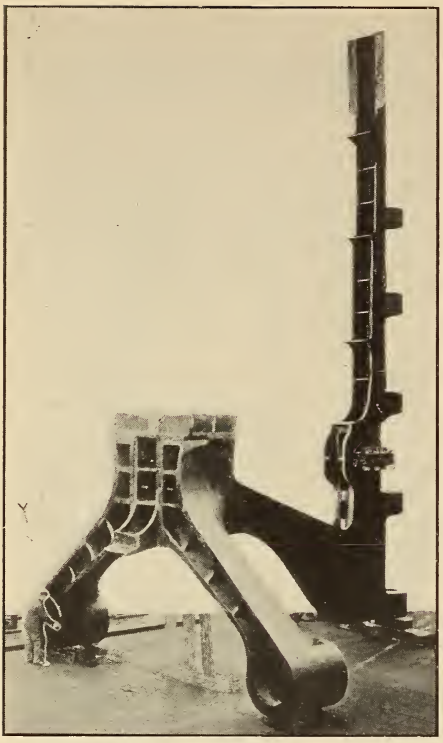


STAYS FOR PROPELLER SHAFTS, S.S. IMPERATOR, HAMBURG-AMERICAN LINE

BUILDING THE LARGEST SHIP IN THE WORLD

IN this age of superlatives, of lofty skyscrapers and mammoth ships, it is difficult to surprise one with a mere recital of measurements, however large. The accompanying illustrations, however, will prove an exception to this rule and come as a surprise even to those familiar with giant constructions of every kind. The castings shown in the accompanying photographs are details of the S.S. *Imperator,* of the Hamburg-American Line, the largest ship in the world, which will be launched at the Stettin yards, Germany, in May.

The enormous upright is the rudder post of the great liner, attached to which are the stays for the propeller shafts. The casting, which is in two parts, weighs 100 tons. An excellent contrast is afforded by the figure of the workman at the lower right-hand corner of the casting. This upright, on which hinges the great rudder of the ship, measures 53 feet in height, or rather more than the height of the average city house. The enormous size of the



RUDDER POST, SS. IMPERATOR, HAMBURG-AMERICAN LINE

rudder, which will control the ship's course, may be guessed from this huge hinge.

The statement that the *Imperator* will be equipped with engines developing 70,000 horse-power fails to impress the layman. But a glance at the stays will give a sense of the power of the great propeller shafts which may be gained in no other way. The *Imperator* is a quadruple-screw ship, so that even these stays indicate but half her equipment. The raising of this casting and its accurate adjustment evidently require extremely powerful machinery.

With these huge details of the great liner before one, the other dimensions gain a new significance. The *Imperator* measures 900 feet in length and 96 feet in width, and has a tonnage of 50,000 and a displacement of 72,000 tons, and will have a speed of 22½ knots. She has nine decks above the waterline, and will accommodate 4,250 passengers and a crew of 1,000, a total of 5,250 souls.

POWER PLANT AND LIGHTING OF GIRARD COLLEGE, PHILADELPHIA

GIRARD COLLEGE, located on Girard avenue, is one of the particular points of interest in the city of Philadelphia. It was founded by Stephen Girard and the first 100 pupils admitted in 1848. The bequest was left to the city of Philadelphia, as trustee, for the education of poor white male orphans from Pennsylvania, New York City and the city of New Orleans.

A peculiar feature of the provisions of endowment was that no clergyman should be allowed to enter the grounds. This restriction was made by Girard, it is said, not from any feeling of hostility against the profession, but in order to prevent the minds of the young orphans from being subjected to the strife of sectarian controversy.

Boys are admitted between the ages of six and ten years, and are compelled to leave before becoming eighteen years of age. They are clothed, fed and taught practical trades without any expense whatever to the pupils or their guardians.

The boys are examined regularly, physically as well as mentally, and their health is very carefully looked after.

As an example of the broad scope of the equipment provided for the

boys' welfare may be mentioned the recently installed dental department, which is said to be the finest in the world, where the teeth of the boys are examined at regular intervals.

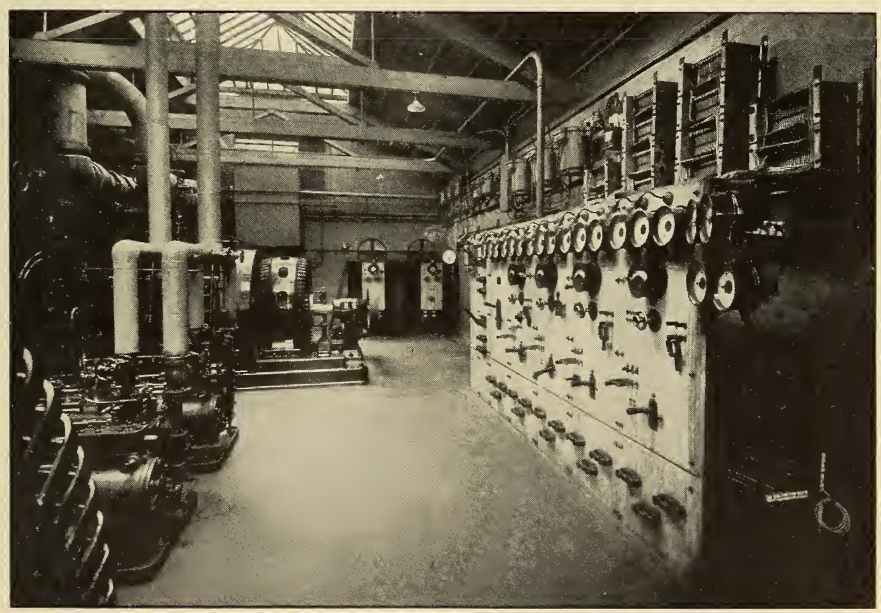
The cost of running the institution amounts to about $500,000 annually, which sum is derived from the estate, consisting of $5,000,000, left to the college by its founder.

The grounds embrace 40 acres, and are surrounded by a stone wall 10 feet in height.

Electric energy for supplying the lights and motors driving the various shops and laundries throughout the grounds is generated in a power house located in the western end of the enclosure.

ones are of 145 kilowatts capacity and driven by 16″ x 27″ x 16″ engines, and the two smaller ones are driven by 11″ x 19″ x 11″ engines. The exciters are belt-driven from pulleys on the generators, being of four and seven and a half kilowatts capacity, respectively, for the smaller and larger machines. Water is pumped from the city mains through a water heater to the boilers, which constitute a battery of 2,000 horsepower.

The switchboard consists of seven panels of blue Vermont marble, four being for the control of the generators, one for the total load, one for arc lighting, and one for the voltage regulator.



ENGINE ROOM POWER PLANT, GIRARD COLLEGE, PHILADELPHIA, PA.

Above is given a view of the engine room, showing one of the generators, the switchboard, the two constant-current regulators for the metallic flame arc lamps and the boiler feed pumps.

There are four three-phase, 60-cycle, 2,200-volt generators direct-connected to Westinghouse automatic compound engines. The two larger

The generator panels are placed on the right when facing the board, and contain three A. C. ammeters, one exciter ammeter, field switch, one exciter paralleling switch, one oil switch, and three expulsion type fuses mounted on the sub-panel. Ground detector, voltmeter and synchronizing receptacles are also provided.

ONE OF THE SEVEN TOWERS EQUIPPED WITH WESTINGHOUSE METALLIC FLAME ARC LAMPS, GIRARD COLLEGE, PHILADELPHIA, PA.

The exciter bus-bars are so arranged that excitation for any generator can be furnished from any exciter.

The totalizing panel contains three ammeters, one triple-pole, double-throw automatic circuit-breaker and three expulsion type fuses.

The arc lighting panel contains two double-pole, double-throw oil switches and four main fuses for the control of the circuits from the generators to the constant-current rectifier regulators.

The regulator panel contains only the TA voltage regulator for maintaining a constant voltage on the system.

The voltmeter bracket at the left-hand end of the board contains an exciter voltmeter, and the one at the right-hand end has mounted thereon a synchroscope and one voltmeter each for the line, the bus and the incoming machine.

The arc lighting apparatus consists of the well-known Westinghouse-Cooper Hewitt rectifier, constant-current regulating transformers of twenty-five lights capacity, each equipped with a blue Vermont marble control-panel mounted in front of the rectifier. These regulators are fed from the alternating-current bus-bars through the panel in the main board and an automatic circuit

POWER PLANT, GIRARD COLLEGE

breaker, and, in turn, deliver a constant direct current to the arc lamp circuits, of which there are two, one having twenty-two lamps and the other twenty-four.

The conversion is accomplished by means of the Cooper Hewitt rectifier bulb. The constant-current regulator maintains a very steady and uniform current.

The plant is operated twenty-four hours a day, under the direction of the chief engineer, who has charge of all the engineering work of the college. The operating force consists of two engineers, eight firemen, one electrician and one trimmer.

A tunnel, running from the power house for a distance of about three-quarters of a mile, carries all the wiring, steam and hot-water pipes for the laundry and other purposes. Branches leave the tunnel at various points for supplying the different buildings.

The majority of the motors used in the laundry and workshops are operated by direct current obtained through two motor-generator sets. This system is used because these direct-current motors were purchased some time previous to the installation of the present alternating-current plant, which was about three and one-half years ago.

Decidedly the most novel feature of the installation is the illumination of the ground by use of Westinghouse metallic flame arc lamps mounted on steel towers, a view of one of which is shown on another page.

These towers are 130 feet in height, and there are seven of them distributed throughout the grounds. Each tower has six lamps mounted at the top. Steps are provided on the framework of the tower to enable the trimmer to reach the lamps.

This form of lighting has been in use in the grounds for a number of years, and when, in 1910, it was found necessary to replace the old towers, it was decided to retain this system.

The entire electrical equipment, including the generators, switchboard, arc-lamp rectifiers and arc lamps, were manufactured by the Westinghouse Electric & Manufacturing Company, and the engines were supplied by the Westinghouse Machine Company.

THE QUARTER-CENTURY CLUB

Eight employees of the Dodge Manufacturing Company, having passed the twenty-fifth anniversary of their first day in the company's service, have been formally initiated into membership of the Quarter-Century Club.

The organization, which limits its roster to those that have seen twenty-five years or more of service for the manufacturers, was organized February 28, 1910. Although at the time of founding the club necessarily had a number of 25-year men without waiting for the passage of time, several members had been received up to last night. In the first part of 1911 President M. W. Mix, of the Dodge plant, was received with elaborate ceremonies into the fold of the club.

Following the formal reception as full-fledged members of the Quarter-Century Club the insignia was pinned and certificates of membership were conferred on the eight candidates.

Among the club roster are several men who have been with the company for more than thirty years. These include Charles Endlich, secre-

(Concluded on page 80.)

Team Work in Power Transmission

IT is well understood in various departments of effort that much loss follows the lack of concerted action. The hydraulic engineer knows that the internal work in flowing water, creating eddying action and general interference with flow, is one of the principal sources of loss, while the electrical engineer has found similar wasteful action in the electric current. The modern student of efficiency finds that one of the principal means available in improving methods of work is the elimination of interfering actions and the development of proper co-ordination of details. Thus, sailors long ago discovered that the utterance of some rhythmical cry or crude melody enabled them so to time their effort in hauling on a rope that the simultaneous pull, so necessary to the full effect, could be secured better than by any other plan. Similar ideas will be met in many departments of industry, but there are numerous instances in which the neglect of such united action results in material loss and in which intelligent combination would produce great improvement.

There is no need for impressing these facts upon those who are interested in sport. The necessity for "team work" is so well understood in such games as baseball, football, rowing, and the like, that a large part of the training for such purposes is devoted to the one aim of getting a number of men to act with almost perfect unanimity toward a common purpose.

It is most desirable that the engineer should realize the importance of team work in some of the departments of his field in which it has hitherto been given less attention than it demands, and there are several methods by which this may be done.

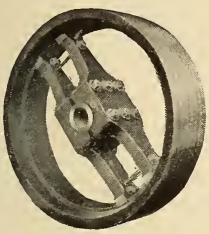
In the handling of men the team work idea is well understood to be a matter of training, and the perfection to which this can be carried is well seen in such matters as the conduct of a baseball game; but with mechanical appliances it involves both the design and the installation of the apparatus. The modern workshop should be so planned and equipped, for example, that the product should pass from machine to machine in almost continuous sequence, just as, in the steel works, the metal goes from furnace to converter, to soaking pit, to rolling mill, to shipping yard, practically flowing at the same rate after it has become the solid finished product as it did in the earlier molten stages.

In the case of power transmission a similar continuity of action is necessary to the maintenance of maximum efficiency. Every resistance along the route by which the power travels from prime mover to tool means a deduction from the effective result, and the only way in which such resistance can be kept down lies in the united perfection of action of each element.

When, as formerly, little or no special attention was given to the transmission and the various parts were procured at different times, from various sources, and put up in haphazard fashion, the result, so far as efficiency is concerned, was exceedingly low; and it was found, in the few instances in which the actual ratio of power output to input was measured, that nearly one-half was lost in transmission.

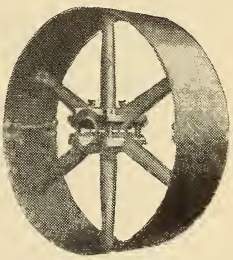
The modern method, considering the transmission system as a whole, composed of shafting, pulleys, hangers, bearings, clutches, etc., designed and constructed according to established standards and critically tested before erection, enables a very large proportion of loss to be avoided, thus either delivering more power to the operative machinery or permitting material reduction in the original cost of power generation. This result is the natural development of the application of engineering skill to the lessons of experience, and its wise use has much to do with the efficiency of the modern power plant.

DODGE



Dodge
Wood Split Pulley

Standardize Your Transmission Equipment



Dodge
Iron Split Pulley

OPERATE ON A 100 PER CENT. EFFICIENCY BASIS

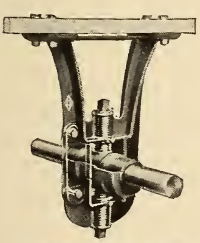
ONE of the greatest advantages gained in a factory, laid out along modern lines, is the economical distribution of power.

The transmission equipment is planned, built and installed as a complete unit—designed as a whole to meet the individual problem in the most efficient way, but standardized as to its component parts.

Most of the larger manufacturers have fixed upon the DODGE LINE because it provides this standardization carried out to the last degree of completeness and perfection. It embraces everything for the mechanical transmission of power—includes the advantage of interchangeability wherever possible, the split feature, the economy of self-oiling bearings, and independent control by means of friction clutches.

Some of these manufacturers have built new plants, which are entirely Dodge-equipped. Others are standardizing by a gradual transition to the DODGE IDEA as the old apparatus wears out or additions become necessary.

If your problems are complex, put them up to the Dodge Engineers, men of wide experience. They will be solved without expense or obligation. Feel perfectly free to write us. Why not now?



Dodge Drop Hanger,
Adjustable

DODGE MANUFACTURING CO.

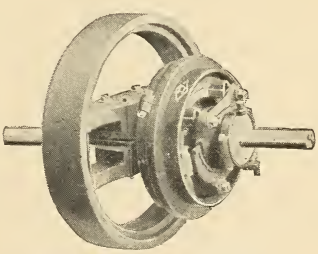
General Offices and Factory

MISHAWAKA, - - INDIANA

Branches and District Warehouses Carrying the Full Dodge Line in Stock

New York
21 Murray Street

Minneapolis
202-204 Third St., South



Dodge Friction Clutch,
With Pulley

Boston
137-139 Purchase St.

Cincinnati
126-128 West Third St.

Chicago
208-214 South Clinton St.

St. Louis
507 North Main St.

Pittsburgh
337 Second Avenue

Philadelphia
815 Arch Street

Atlanta
54-60 Marietta St.

AGENCIES IN OTHER LEADING TRADE CENTERS

The Electrification of the Quarry

PERHAPS few lines of industry have been more improved in means and methods employed and in results accomplished than has been the cutting of stone from its native bed. This is one of the primitive, as it seems also to be one of the most enduring, of man's occupation, coming next, perhaps, to the hewing of wood and the drawing of water. These two latter—the getting of fuel to keep warm and to cook by and the conveying of water to drink and bathe in, cited originally as the most menial and enslaving of occupations—have been dignified into the life-work of the great engineers, and the getting of building and monumental stone is now similarly elevated.

The first cutting of stone could scarcely have been called cutting at all. It was a splitting or tearing away of fragments whose shape and dimensions were largely determined by chance, much as a hungry man might tear away his mouthfuls of bread from a stale and crusty loaf. What we take from the loaf now is carved in regular slices and the loaf itself is respected and left in perfect condition for the next carving, so that it might gladden the heart of a careful housewife to look at it. In the cutting of the stone now there is no wasting of the material, and the pieces got out can be shaped and finished to predetermined dimensions with a minimum of labour.

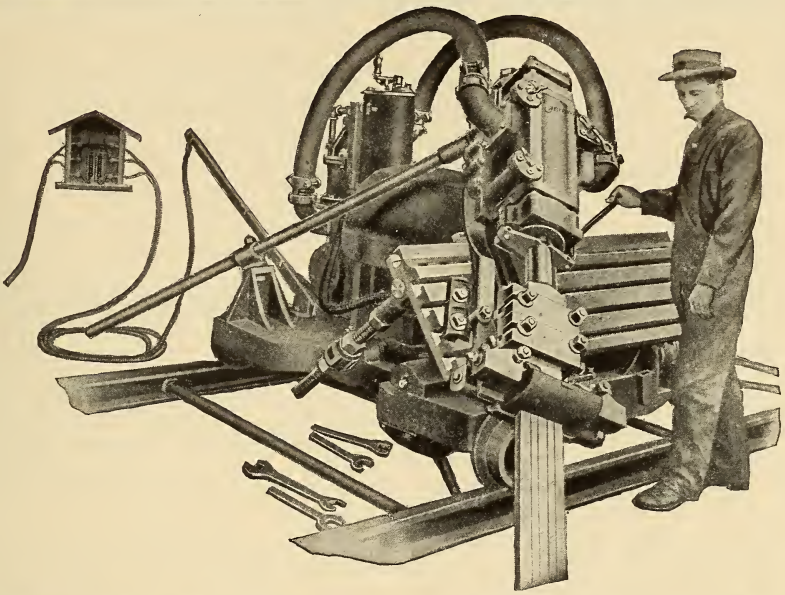
The stone channeler has been the most active and effective agency in the development of the modern quarry along the lines of precise, systematic and profitable operation, and the sight of a great plant where the channeler dominates cannot but be gratifying to anyone who has any appreciation of the difficulties and the exactions of this line of work.

The stone channeler, while unique in its line of work from the first, has had its long period of development and of approach to the perfection of design and action, which is never quite attained. It has grown larger and heavier and more elaborate, but all the while it has been more especially acquiring the knack of doing more and better in its special line.

The channeler has been quite generally steam driven, each having its own boiler as an integral part of it, and being thus self-contained and independent of everything except an unfailing supply of fuel and water. The firing of the boiler and the maintenance of the supplies for it have, of course, entailed much extra cost of operation, a feature most desirable to avoid, and so other channelers have been operated very satisfactorily with compressed air; but here also a compressor and pipe lines were to be provided and the accompanying cost of them.

It must have been a most welcome consummation when the electric air drive and the track channeler got together for their mutual benefit and for the comfort and profit of all concerned. These are so evidently adapted to each other that it might be said they could not long have been kept apart in any case. The channeler churns along in a livelier way than ever before, does more work and requires less than half the power to do it, and there are no offsetting disadvantages to be compromised with.

Most important of all, the coming of the electric air drill, and especially of the electric air channeler, makes it possible to use one system of power transmission for the entire plant. At the present writing the electric equipment is a necessity for lighting, and for power purposes it approaches the ideal. Quarries are quite apt to be located within reach of water-powers, which can be utilized to drive generators, thus providing the cheapest power known. It is a curious thing that a special compressed air invention—which, after all, the electric air drive distinctly is—should so help to promote and extend the reach of the electric current.



The Most Progressive Quarries Are Adopting "Electric-Air" Track Channelers

We have claimed from the beginning that the "Electric-Air" Channeler would cut more stone with less power and at less total cost, than any other channeler built.

Here are some of the big stone producers whose orders for "Electric-Air" Channelers show that our claims are correct.

Vermont Marble Co	55 Machines
Colorado Yule Marble Co.	10 Machines
Dover White Marble Co.	5 Machines
Crystal River Marble Co.	3 Machines
Furst-Kerber Cut Stone Co.	2 Machines
Others	13 Machines
Total	88 Machines

You will find these splendid channelers just as profitable in your work. Shall we send the pamphlet?

NEW YORK **INGERSOLL-RAND CO.** LONDON

Offices in All Principal Cities of the World

COMPRESSORS ROCK DRILLS COAL CUTTERS PNEUMATIC TOOLS

1-E.A.C.

Cutting the Cost of Cutting Steel

ONE metal may be cut by another only when the latter is harder and more capable of maintaining a cutting edge than the former. This may sound like a truism, but when examined more closely it will be found far deeper than appears on the surface. The material known as steel is a substance of properties which vary greatly, according to the small proportions of other elements with which it is combined; and the influence of these elements, together with the heat treatment which may be applied, governs very largely the effectiveness of a tool steel, considered as an implement for cutting other metals.

It must be remembered that the portion of a tool which is actually engaged in cutting forms a very small portion of the entire piece, and the same is true when the wear of two members of a machine, rubbing against each other, is considered. It is by no means necessary that the entire mass of a tool should be composed of hardened tool steel of the highest grade and cost, or that the bodies of two gear wheels demand material capable of resisting the sliding frictional action which exists upon the faces and flanks of the teeth.

These conditions have brought the question of the constitution of certain portions of articles made of steel to the attention of engineers and metallurgists, and the result has been the development of some remarkable applications of scientific methods to practical service.

A large portion of the cost of machining articles made of steel lies in the cost of the tools by which the work is done, and if this cost may be concentrated upon the very small part of the tool in contact with the work, it is evident that the entire cost may be proportionally reduced. This means that if the entire tool is made of soft steel, itself comparatively inexpensive, and by reason of its softness capable of being readily worked into the desired form, and then, by the process of infusion, the proportion of carbon, tungsten, chromium and other hardening elements incorporated with the cutting portion, the tool itself will really be better than if made in the more expensive manner, involving the use of the highest grade of tool steel throughout.

That this may be done has been amply proved, and the ease with which a high-carbon alloy-tool steel edge may be produced upon a piece of low-carbon, low-cost soft steel renders it possible to effect large economies, both in the production of cutting tools themselves and in the use of the materials upon which they operate.

The applicability of the infusion process to the production of resistant gear wheels is an interesting indication of the manufacture of a high-grade product at a reduced cost. Formerly it was maintained that gear wheels with cast teeth wore better than those in which the teeth were cut out of the solid metal, principally because the hard skin of metal upon the surface of the cast teeth gave greater endurance than the softer interior metal. By using soft steel in the first instance, however, and cutting the teeth accurately in this readily workable material, and then subjecting the cut gear wheel to the infusion process, a glass-hard metal is made to a considerable depth.

The entire tendency in modern machine design and construction is the use of material of the highest quality and most appropriate in the proper place and the avoidance of unnecessary or difficult machining at the wearing points. Under such circumstances the development of a process which enables the character of the material to be controlled after the operations of machining have been effected places in the hands of the engineer a means of attaining the highest results, while at the same time materially reducing the cost.

FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

OF THE
INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

IN spite of certain disturbing factors, business conditions continue to improve. The fact that this betterment has gone on in the face of labour disorders and political unrest indicates that fundamental conditions warrant good times.

One of the most striking features in connection with the present situation is the efficiency and economy with which business is being conducted, thus largely accounting for the increased percentage in net earnings of many institutions. There is apparently a stronger demand for funds for business purposes. This is indicated by bank clearances and firmer money rates. Merchants are buying more freely than heretofore, and the purchasing departments of business enterprises generally are displaying greater confidence in the future, with the result that the petty purchasing policy, too long adhered to, is being displaced by a broader and more normal one.

Speculative Wall Street operators continue to play to unenthusiastic audiences, and are attracting as little attention as some of our Presidential booms. The investment side of the market continues fair, and dependable securities, netting 5 per cent. and better, meet with a ready sale. Speaking of Presidential booms, it is interesting to note that the present campaign, though bitter in spots, is seldom referred to as a menace to trade expansion.

There seems to be a well settled conviction on the part of the public that our storm-tossed political ship will again prove equal to her quadrennial endurance test. The calm and clear-headed attitude assumed by the average voter indicates that he has done considerable thinking on his own account and is not unduly alarmed by the pessimistic prophecy of partisans.

The one question at issue in which the people generally are most interested is how certain necessary reforms can be brought about with the least possible disturbance to great business interests. All unbiased men in and out of politics recognize the necessity for close and practical supervision of powerful corporations, but it has been discovered, to the satisfaction of all who are not blinded by selfish ambitions, that the present method of disorganizing commercial institutions has failed to accomplish the desired end.

We cannot ignore the fact that the present conflict between business and politics transcends party lines and

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makes to-day big with opportunities for those political leaders who have the courage and good sense to lean upon the powerful influence of public opinion rather than the crumbling power of party bosses.

Slowly but surely the voter is finding a way of directly expressing his views, and, if we read aright the signs of the times, the party that is destined to endure and dominate in this country is the one that rises most nearly to the level of the people's hope.

Question—What do you think of the dividend possibilities of Norfolk & Western?

Answer—There are few railroad stocks that have better investment value behind them than the Norfolk & Western. The management is dominated by the Pennsylvania system, and while we occasionally hear rumors of the dividends being increased, no definite information is at hand to justify such rumors. Assuming that matters continue to go as well with the road in the next year as they have in the past, it is reasonable to assume that an advance in the dividend rate will be in order.

On April 22 the advance in structural steel and steel plates from $1.20 to $1.25 per hundred pounds went into effect. The Bethlehem Steel Corporation is following the lead of the United States Steel Corporation in advancing its price.

Nearly $150,000,000 was expended for road work in the United States in 1911, according to estimates recently made.

It would appear that the increased cost of living is not confined to America. Since 1900 the price of bread in Germany has advanced 11

In the heart of the New Business Centre of the U.S.

Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

The Chelsea Exchange Bank

Located at

Thirty-fourth St. and Eighth Ave.

NEW YORK

Safe Deposit Vaults. Boxes $5.00 per year up

A Continually Growing Bank in a Continually Growing District

per cent.; pork, 33 per cent., and beef, 13 per cent.

Question—What do you think of stocks in recently organized insurance companies?

Answer—Most of the insurance companies recently organized and now offering stock to the public are experimental promotions, and we would not advise anyone to invest in them.

Large copper interests in the United States are earnestly denying that there is an abnormal surplus of unrefined material on the market. It is alleged that 70,000,000 pounds is the increase of mine output over refinery during the past eight months. Dependable authorities agree that this figure is an exaggeration; apparently, somebody is trying to depreciate the recent improvement in both the copper stock and metal market.

Annual Meeting of the Joseph Dixon Crucible Company

At the annual meeting of the stockholders of the Joseph Dixon Crucible Company, held at the company's main office in Jersey City, N. J., Monday, the 15th inst., the retiring board of directors, consisting of Geo. T. Smith, William Murray, Edward L. Young, William H. Corbin, Geo. E. Long, William G. Bumsted and Harry Dailey, was unanimously re-elected.

Officers elected for the ensuing year are as follows: President, Geo. T. Smith; vice-president, W. H. Corbin; treasurer, Geo. E. Long; secretary, Harry Dailey; assistant treasurer, and assistant secretary, J. H. Schermerhorn.

There were voted 9,304 shares of a total of 10,000. A number of stockholders attended the meeting, and expressed themselves as well pleased with the company's showing and with future prospects.

FREE REAL ESTATE MARKET LETTERS

ORIGINALLY sold for one-tenth cent an acre — recent sales at the rate of twenty-five million dollars an acre—such is the history of this wonderful Manhattan Island.

The marvelous growth of New York City and its suburbs, the remarkable increase in population (about 1,000 persons daily) with consequent enhancement of value are unprecedented in extent—unequaled in scope.

Billions of dollars are being made by realty experts and those associated with them. Perhaps you are one of the many who share these profits — if so, some of your money goes to make up the $10,000,000,000.00, now invested in New York Real Estate.

There is a medium through which you can keep informed regarding real estate and real estate securities.

We issue regularly a **Real Estate Market Letter** — an unusually interesting review of all important realty happenings in New York City and vicinity. Tells in a readable way, just the things which enable you to investigate before you invest—not afterwards. A reading of it should be to your decided advantage.

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FINANCIAL NOTES

The American Infusion Steel Process Company 60 Broadway, New York, reports a constantly growing demand for "Stelpro," their new scientific hardening mixture, which is proving most successful as a simple means for hardening steel by infusion. Its application requires no elaborate equipment, difficult process or skilled workmen, while it has been found to give most wonderful results, and affords great saving in manufacturing costs. They report inquiries and orders from nearly all over the world.

According to reports, there are now more than 650,000 automobiles in use in the United States.

It is stated by President Willard, of the Baltimore & Ohio, that the $60,000,000 now being spent for construction work on the road will so improve its condition that the increased interest charge will be easily earned.

On the ground that a lack of freight cars and shipping facilities are hampering the development of the automobile business in Detroit, the Chamber of Commerce is trying to induce the Pennsylvania Railroad to enter the city.

The Hamburg-American Line has been quick to draw a lesson from the *Titanic* catastrophe. It has decided to increase the number of lifeboats on its steamers, although they already carry more than are required by the German law, and it will also improve all life-saving appliances, so that under any circumstances every person on board can be accommodated. This has been done, according to the management, although the German legal requirements are much more stringent than the British in regard to lifeboats and have been heretofore thought sufficient by the German authorities.

San Francisco will spend the neat little sum of $80,000,000 on the Panama - Pacific Exposition. The State of California has authorized $9,000,000 for waterfront improvement in addition to $5,000,000 for the fair.

It would appear that the Pere Marquette Railroad has many troubles ahead of it. According to its last report, it is living up to its reputation for high cost of operation. The road is very deficient in equipment. The operating ratio for the month of March was 92.5 per cent., against 83.53 per cent. a year ago.

The Chicago, Milwaukee & Puget Sound Railroad started work this month on a three-mile tunnel through the Cascade Mountains, the estimated cost of which is $5,000,000.

Question—Would you advise selling International Mercantile Marine preferred?

Answer—We would not advise selling this stock at this time. The loss of the *Titanic* has, to some extent, affected the market, which is never active.

The American Locomotive Company has recently taken orders for fourteen locomotives to be shipped to Brazil. The Central Railroad of Brazil were purchasers of eight and the Bahia Minas purchased six.

Question—Where could we secure dependable information regarding Texas land and industrial opportunities?

Answer—We would suggest that you write to the Rio Grande Valley Company, No. 334 Fifth avenue.

There is very persistent talk of new financing in connection with the Bethlehem Steel Corporation. It is estimated that the amount involved in the new financial plan will reach $40,000,000. However, well-informed

people hold the opinion that this is an exaggerated figure.

The Chicago office of the Niles-Bement-Pond Company will be removed May 1 from the Commercial National Bank Building to the McCormick Building, 332 South Michigan avenue.

The announcement made last month by the Debenture Corporation of New York, 334 Fifth avenue, to the effect that it would discontinue the sale of its six per cent. profit-sharing real estate bonds after disposing of the present authorized issue, of which there remained on April 1 about $60,000, has attracted a great deal of attention in real estate and investment circles. This step on the part of the Debenture Corporation of New York greatly enhances the value of its bonds and has been most favourably commented upon. The bonds are very generally regarded and recommended as a good business investment.

Recent orders taken by the Buffalo Forge Company, Buffalo, N. Y., for mechanical-draft apparatus of considerable size include, among others, the Combria Steel Company, Johnstown, Pa.; the American Smelting & Refining Company, New York, N. Y.; the Burgess Sulphite Fibre Company, Berlin, N. H.; Knickerbocker Portland Cement Company, Hudson, N. Y., and several export orders from their agents in Germany, Japan and South America. The Buffalo Forge Company reports the export business as particularly active so far this year, and with excellent prospects of exceeding any former season.

The continued increase in railway construction in India should make a corresponding growth in the demand for good steam coal, and leads to the development of coal mining in India.

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OFFERS SUPERIOR ACCOMMODATIONS AT MODERATE RATES

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All modern conveniences, absolutely fireproof, a few minutes' ride to Theatres and Shopping District by elevated road, surface lines and Fifth Ave. stage. Subway express and local station at door.

S. L. ROOT, MANAGER

Attractive Summer Rates

President Topping, of the Republic Steel Company, recently stated that his company had experienced an increase in business as a result of the cut in prices, but that profits did not keep pace. The Republic Company was the first to cut prices last year and has taken a prominent part in the fight between the independents and Steel Corporation regarding freight rates.

The Great Northern Railroad management has left out the United States Steel Corporation in placing its 1912 rail orders. Presumably, this is due to the displeasure of the Great Northern interests over the cancellation of the ore contract by the Steel Corporation.

Pine Orchard, Connecticut

is situated directly on Long Island Sound, 84 miles from New York City and 12 miles from New Haven.

This attractive resort, where you would like to live this summer, offers nearly all that any one could desire in the way of out-door sports and amusements, with its fishing, bathing and boating, also country club with lawn tennis courts, clock golf and a "sporty" golf course, splendid macadamized roads for automobiling and driving.

I live there myself during six months of the year, besides spending many pleasant week-ends during the winter. At the suggestion of some of my neighbors this advertisement is inserted for the purpose of interesting a few more congenial people, in order that desirable tenants may be found to occupy the few cottages unrented.

If a shore-front house surrounded by grass, trees, woods and country seems to appeal to you perhaps you will want to know more about these roomy houses. Everything that makes housekeeping easy in the way of city water, gas, electric lights, telephones, baths and open fire places is there.

Pine Orchard is accessible—yet retired. The grocer, butcher, milkman, baker, iceman and newsboy, make daily deliveries, but the usual fuss and conventional restrictions of summer resort life are absent.

If this sounds "too good to be true" call and see or write for photographic proof and judge for yourself.

EUGENE E. ADAMS
334 Fifth Avenue
New York City

Factors in Foreign Trade

The Bureau of Manufactures now has issued a bulletin that will, no doubt, find a permanent place on the desk of every manufacturer interested in foreign trade. In its 56 pages will be found answers to questions asked by every manufacturer sending out trade literature or opening correspondence with foreign firms: What language is it best to use? In what currency and what weights and measures should prices be quoted? What postage should be placed on the catalogue or the letter? Can I prepay a reply from the prospective customer? Is there a parcels post?

The bulletin answers these and other questions for each country in a concise manner; the reader can put his fingers on the information sought without hunting through a mass of detail that he does not want. Supplementing these statements are tables for converting the money of foreign countries into that of the United States; also, a comparison of prices for countries in which both the monetary unit and the units of weight and measure differ from those used in the United States. For example, the latter tables show the reader at a glance what is the comparative price per meter in Mexican currency of a cloth quoted at 50 cents per yard in United States currency, or the price per pound in United States money of an article quoted at 30 francs per kilo in French currency.

Currency conversion tables and price comparisons are given for over thirty countries. Foreign postage rates and the parcels post regulations are summarized, and a list is given of the countries in which international reply coupons are valid.

Copies of the bulletin, which is entitled "Factors in Foreign Trade," are available for distribution, and those desiring it should make application to the Bureau of Manufactures, Department of Commerce and Labour.

Centrifugal Air Compressor Sales

The General Electric Company reports the following sales of centrifugal air compressors, the sets varying from 10 to 50 horse-power:

For use in connection with oil-burning furnaces: Two sets to the Michigan Smelting & Refining Company, Detroit, Mich. (repeat order); one set to the Warren Tool & Forge Company, Warren, Pa.; one set to the Mount Vernon Car Company, Mt. Vernon, Ill. (repeat order); two sets to the Thatcher Glass Company, Streator, Ill.; one set to the Harley-Davidson Motor Company, Milwaukee, Wis. (repeat order); one set to the Welsbach Light Company, Gloucester City, N. J. (repeat order), and one set to the Cleveland Metal Products Company, Cleveland, Ohio.

Also one set to each of the following for use with pneumatic ash conveyor systems: S. D. Warren Company, Cumberland Mills, N. C.; Government Railways, New South Wales; Corn Products Refining Company, Pekin, Ill.; Edward W. Rieck Company, Pittsburg, Pa., and the Peoples Power Company, Moline, Ill.

A 100 horse-power set has been sold to the La Clede Gas Light Company, St. Louis, Mo., for blowing a water gas generator.

The Massachusetts Gas and Electric Light Commission recommends to the Legislature the following act: "A corporation organized under the business corporation law shall not have the authority of the general court to own or control more than 10 per cent. of the stock of a corporation organized under the general or special laws of the Commonwealth for the purpose of carrying on within the Commonwealth the business of a gas or electric light, heat or power plant."

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER
ALBANY, N. Y. Industrial Agent

If You Use the Wires

YOU NEED

The Western Union Telegraphic Code

For General and Technical Messages

It Will Reduce Your Bills

The volume will be submitted to responsible firms upon request.

APPLY TO

International Cable Directory Co.
59 Pearl Street, New York
LONDON PARIS HAMBURG

The Quarter-Century Club

(Concluded from page 63.)

tary and treasurer, and W. J. Chesbro, superintendent wood pulley shops. Officers elected to serve through the ensuing year are: W. B. Hosford, first vice-president of the company, president; W. J. Chesbro, vice-president; Fred Yost, assistant superintendent wood pulley shops, secretary. The club now has thirty-one members.

The Francis J. Plym Fellowship in Architecture

Second Competition, 1912

By authority of the Board of Trustees of the University of Illinois the committee in charge announces the second competition for the award of the Francis J. Plym Fellowship in Architecture. The value of the Fellowship is one thousand dollars, providing one year of travel in Europe for the study of architecture.

The competition is open to all graduates of the Department of Architecture of the University of Illinois who will be under thirty years of age on the 1st day of June, 1912.

REGULATIONS TO GOVERN THE AWARD

Persons wishing to take part in the competition must notify Professor Frederick M. Mann, Department of Architecture, University of Illinois.

The competition will consist of a preliminary and a final exercise in architectural design.

The preliminary exercise will be open to all who are eligible, as defined above, and who send in the required application. This exercise will consist of a problem in design to be executed in the period of three days. Candidates may do their work locally or under supervision approved by the committee.

The committee will select not more than the four best designs submitted in the preliminary exercise, and the final exercise will be limited to the authors of the designs thus selected.

The final exercise will consist in a more extended exercise in design, to be executed within the space of about five weeks.

The committee will select the best design submitted in the final exercise and will recommend its author to the trustees of the university for appointment to the fellowship.

The designs submitted in both the preliminary and the final exercises must be the competitor's own conception, and the drawings must be the work of his own hand. A written statement to this effect must be submitted with the drawings.

The winner of the Fellowship must sail for Europe not later than the 1st day of September, 1912, and must remain abroad and pursue the study of architecture, following a plan approved by the committee, for the full term of one year, and he must not accept remunerative employment during the term of the Fellowship.

The competition drawings and the foreign envois and sketches will be first exhibited at the University of Illinois and may be retained by the University as long as desired for purposes of exhibition and instruction.

A trip of inspection was taken during the week beginning April 1 by senior students in electrical engineering, mining engineering, ceramic engineering and industrial chemistry of the University of Illinois. The party visited the Illinois Steel Company's works and the mills of the American Steel & Wire Company, in Joilet; they inspected the power plant development in connection with the drainage canal at Lockport, and spent two days in and about Chicago, visiting some of the pumping stations of the sanitary district, some of the large business houses, the Western Electric Company's works, the Chicago & Northwestern terminal, the South Chicago works of the Illinois Steel Company and the various stations of the Commonwealth Edison Company.

BOOK NOTES

Power House Design

Power House Design, by John F. C. Snell, published by Longmans, Green & Co., New York. 448 pages, 17 folding plates and 186 illustrations. Price $6.00.

A new volume in Longman's Electrical Engineering Series, the author in his preface stating: "The author ventures to hope that the principles and information given in this book, together with the typical examples of modern power houses shown, will be of some use to his engineering brethren, whether civil, mechanical, electrical, or mining engineers.

"He does not claim to have introduced any noticeable originality, but rather to have drawn upon his own experience, and to have collected and classified the experience of other and more eminent engineers. By condensing this information in a practical form in one book, an endeavour has been made to give all the requisite practical information on power-house design, and thus to save the loss of time which results from searching through numbers of textbooks, proceedings of Institutions and the admirable descriptions of power houses in the Technical Press. The information selected has been carefully sifted out by the author's experience gained in various power stations over a period of more than twenty years, and especial care has been taken to avoid errors and to preserve exactitude."

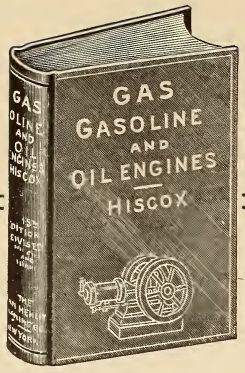
Webster's New International Dictionary: 2,700 pages, 4,000,000 words and phrases, 6,000 illustrations. Price $12 net. G. & C. Merriam Co., Springfield, Mass.

In this volume is presented a really new dictionary of the English language. It is the latest term in the series which was begun by Noah Webster, and which has been steadily and consistently developed under the management of a single publishing house from 1843 to the present time.

For the past six years a large staff of editors has been at work; men carefully selected for their individual qualifications, and so grouped as to cover the whole field of practical lexicography; directed by chiefs who had gained experience in previous revisions of Webster, and reinforced by experts chosen from the highest authorities in literature and science. In general supervision of the whole has been the former United States Commissioner of Education, Dr. W. T. Harris, who was editor-in-chief of the International Supplement of 1900, and who is recognized as a scholar and metaphysician of the highest rank.

The basal principles in the construction of the New International have been: a fuller application of the historical method to the old words of the langauge; an enlargement of the vocabulary, representing the new coinage incident to the world's advance in science, art, literature, exploration, politics; and the addition of general information concerning things, as well as words, making the dictionary not only linguistic, but in its measure encyclopedic.

Beyond its special province of language the dictionary may reasonably be expected to supply much knowledge of a somewhat miscellaneous character. The requisition arises not out of logical or scientific deduction, but from the actual habit of the English-speaking people. If, for example, a reader looks for the common word "skin," it is probably from a desire to be told something more than that the skin is the covering of an animal body, and he will find twenty-two lines of clear and exact anatomical information, with a pictorial illustration and its key, as well as a series of special meanings and phrases, and a group of synonyms. No feature of the dictionary is less amenable to the application of



GAS, GASOLINE AND OIL ENGINES

By Gardner D. Hiscox, M.E.

Just issued. Twentieth edition. The book treats on the theory of Gas, Gasoline and Oil Engines as designed and manufactured in the United States. Explosive motors, stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric Ignition by Induction Coil and Jump Sparks are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. 450 octavo pages, fully illustrated by 351 engravings. Price.....$2.50

MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT

By Oscar E. Perrigo, M.E.

A work of 400 pages, dealing with every problem connected with the building and conducting of a modern factory or shop. The subject-matter embraces the designing of the buildings, the installing of machinery, etc., and the turning out of work. For convenience the book is divided into three parts: The first part deals with the construction and the providing of power, heating and ventilating and lighting; the second part takes up the equipment, both mechanical and administrative, and the third part pertains to management, introducing a simple and efficient time and cost system. Price.....$5.00

HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL

By Joseph V. Woodworth

A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price.....$2.50

PATTERN MAKING

By F. W. Barrows, Practical Pattern Maker

This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price.....$2.00

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exact rules and principles than its encyclopedic matter. But perhaps in no respect has the New International more novelty and value for the average consulter than in this.

It may be said in general that in all branches the work of reconstruction has been radical and comprehensive. Legal terms are treated with a fullness and precision such as has never before been attempted in a general dictionary. The natural sciences have been very carefully treated. Military and nautical definitions are brought fully up to the latest facts. Mechanical and civil engineering and the mechanical arts have had specially competent handling.

Coal Resources of Texas

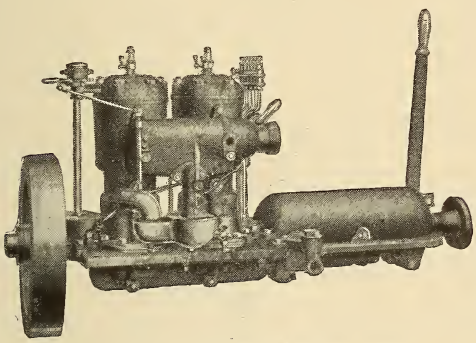
The United States Geological Survey's estimates of the coal areas of Texas show that the bituminous fields known to contain workable coal cover 8,200 square miles, and that 5,300 square miles—not so well known—may contain workable coal. The known lignite areas cover 2,000 square miles, and there are 53,000 square miles, extending from Sabine and Red rivers on the east and north to the Rio Grande on the southwest, which may contain workable beds of lignite. The estimated original supply of bituminous coal in Texas is placed at 8,000,000,000 short tons and of lignite at 23,000,000,000 tons, making a total of 31,000,000,000 tons as the original supply. From this there has been mined to the close of 1910 a total of 20,056,941 short tons, which represents an exhaustion of approximately 30,000,000 tons, the exhaustion being one-tenth of 1 per cent. of the original supply. The supply left in the ground at the close of 1910 would be equal to 19,000 times the production of that year.

The Denver, Northwestern & Pacific Railroad will be extended 390 miles, from Steamboat Springs, Col., to Salt Lake City, Utah, at an estimated cost of $16,000,000.

Marine Engines and Equipment

A Practical Treatise on Correct Design and Construction for Laymen, Experienced Boatmen and Boat-Builders.

This 48-page book, 9 x 12 inches, well written, clearly illustrated by over 100 half-tones and line drawings and handsomely bound, is devoted to a very full description of gasoline engines, and particularly the well-known and largely used Ferro engine built by the Ferro Machine & Foundry Company, of Cleveland, Ohio.



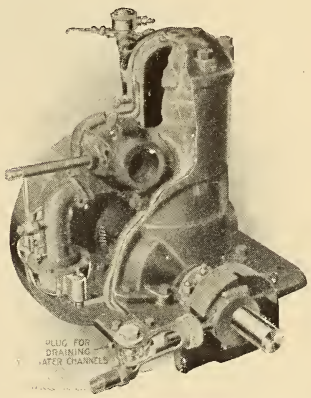
TWO CYLINDER GASOLINE ENGINE, FERRO MACHINE & FOUNDRY CO.

It is a treatise intended primarily for persons without mechanical knowledge, just as the Ferro engine is intended to be operated by people without mechanical training, and will, therefore, prove of great value to the ever-increasing number of persons using internal-combustion engines.

The first treatise on the subject issued by the Ferro Machine & Foundry Company was in 1907, and it met with such a large demand that from time to time later editions were issued, this being the fourth. An insight of the scope of the book can be obtained from the following list of subjects treated:

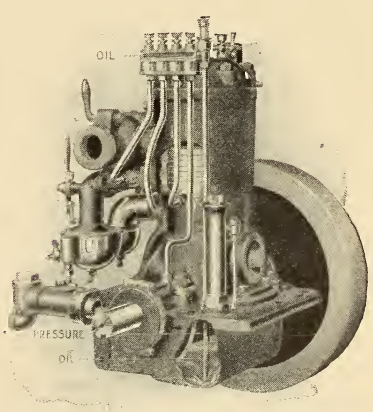
The Gasoline Engine of the Past and Present, How a Modern Gasoline Engine Operates, The Carburetor, Ignition, The Timer, The Make-and-Break System of Ignition, Sources of Electrical Current, Installation of Ignition, Cooling System, Lubrication, etc.

The first chapter contains information of a historical nature con-



SECTION OF FERRO ENGINE, SHOWING COOLING SYSTEM

cerning the development of the internal-combustion engine from the first effort of the Abbé of Hautefeville, France, in 1678, to utilize the power generated by exploding gunpowder for driving moving parts, up to the highly developed engine of our day. The latter portion of the



LUBRICATING SYSTEM, SINGLE CYLINDER FERRO ENGINE

book is devoted to an illustrated description of the Ferro marine engine, describing briefly the design, construction and assembly of its component parts, told in such a man-

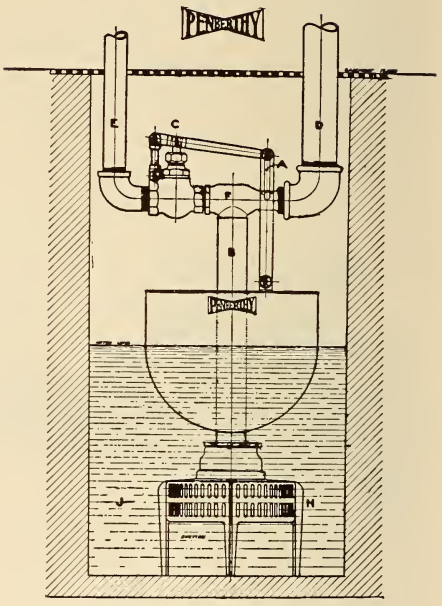
(Concluded on page 85.)

AN AUTOMATIC CELLAR DRAINER

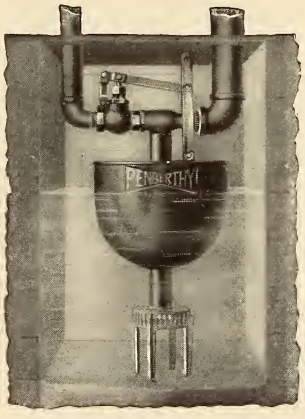
THE Penberthy automatic cellar drainer is a Penberthy water pressure ejector of high capacity, automatically operated by a float - controlled, quick-opening-and-closing valve *C*. This valve is never partially opened; it cannot leak, and allows the ejector to give its greatest efficiency by working to full capacity. The float arms are slotted at *A*, where they connect to the valve lever *C*. This prevents the ejector from operating until the water has raised the float up to the highest point, and, as the water is ejected, they travel down the length of these slots before the weight of the float affects the valve. This allows the machine to work for longer periods and not so often, thus preventing considerable wear and the leakage and dribbling of water, as is common in the majority of drainers.

To enable the installation of this drainer in small holes, or sumps, it has been made as compact as possible. The float, instead of being round, is flat on the top; it has more buoyancy and occupies less space than a round float of the same diameter. Space is further economized by building the float around the suction pipe *B*. This patented feature has the added advantage of being rigid, and overcomes all the trouble of the common loose float. The balance of the drainer is built directly above the float; this not only keeps the whole machine in as small a space as possible, but also keeps all working parts, with the exception of the strainer and float, above the water, thus preventing corrosion or the exterior parts becoming clogged up by deposits of slime, dirt or sediment. The interior parts are prevented from coming in contact with any foreign particles by the special strainer

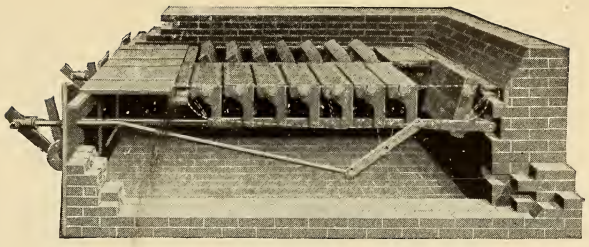
(Concluded on page 90.)



AUTOMATIC CELLAR DRAINER



PENBERTHY AUTOMATIC CELLAR DRAINER



IMPROVED ROCKING AND DUMPING GRATE

An improved feature in a rocking and dumping grate is here shown. It consists of a large rear dump grate, which is operated independently from the main grate surface.

By means of this double-capacity dump grate the largest clinker formations can be quickly and easily disposed of at the rear of the furnace, where combustion terminates.

The residue of combustion must be disposed of after the fuel has performed its heat-producing function, and two ways only are available—namely, to dump into the ash pit or clear out through the fire doors.

In modern furnace practice the dumping process is considered the only right method.

There is a tremendous loss in furnace efficiency by the forward cleaning of the fires, because it disturbs combustion, and with the opening of the fire doors the heat-producing function of the furnace is destroyed, and the loss represents both fuel and labour in getting the combustive areas of the furnace back to a normal active state again.

By referring to the illustration, it can be seen how convenient and easy it is to clean these grates, especially the rear portion, which ordinarily receives the least attention, because it is out of reach of the fireman. But with this wide dump grate it is really the easiest portion of the grate surface to clean, and can be done without extra exertion and exposure to heat and dirt.

A combination of this rocking and dumping feature entitles this grate to recognition as a modern device for coal-burning furnaces; and while it is a hand-firing device, it embodies three prominent features of a mechanically-fed furnace:

1st. The agitation and breaking up of the fuel bed by the rocking movement.

2d. The tendency of the rocking motion to shift the fuel to the rear.

3d. The large dumping grate at the rear of the furnace, which enables the operator to dump the accumulation of clinker and ash.

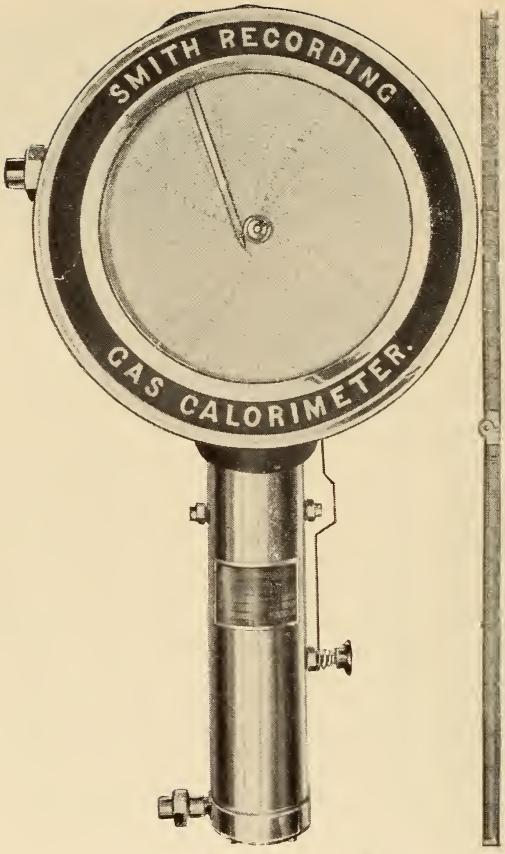
This grate is the product of the Kelly Foundry, of Goshen, Ind. It is made to fit any size furnace and with air space best adapted to the kind of fuel used. It is self-contained, and does not require any alteration in the ordinary furnace to install.

Marine Engines and Equipment

(Continued from page 83.)

ner as to be clearly understood by the layman and of interest to all who use such engines. Included in the work is a glossary of terms explaining technical expressions likely to be unfamiliar to some readers, which makes it of greater practical value to a larger field.

This treatise is well worth owning, and may be obtained by writing the Ferro Machine & Foundry Equipment Company, Cleveland, Ohio, and mentioning CASSIER'S MAGAZINE.



SMITH RECORDING GAS CALORIMETER

A RECORDING GAS CALORIMETER

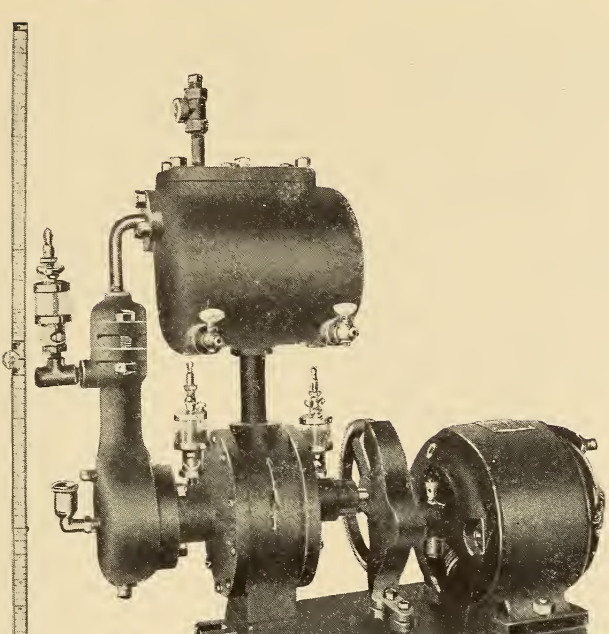
THE Smith recording gas calorimeter is an apparatus for making a continuous record of the heat value of gas. The instrument was designed primarily to record the heat value of producer gas, and in this way to make the operation of producer gas power plants and the application of producer gas to refined heating operations simpler and more reliable.

The Smith recording gas Calorimeter is perfectly automatic. It requires practically no attention, and gives results that are automatically corrected to the accepted standard of gas at 60 degrees Fahr. and 30 inches barometer. The readings are also practically independent of atmospheric conditions.

The equipment consists essentially of two parts—the sampling pump and the calorimeter. The sampling pump is a small power-driven metering apparatus, which delivers continuously a measured and proportionate amount of gas and of ordinary atmospheric air. The gas and air are delivered from the sampling pump through separate pipes to the calorimeter, where the gas is burned in and with the air, and the rise in temperature of the air recorded as a measure of the heat value of the gas.

The instrument being calibrated to read in terms of standard 60 degree

A RECORDING GAS CALORIMETER



SAMPLING PUMP

gas under 30 inches barometric pressure, all readings are automatically corrected to this standard, regardless of the actual conditions under which they are taken. The products of combustion being discharged from the instrument at a high temperature, the readings are always in terms of net or low value.

As a result of all this, readings from this instrument are always comparable with other readings without reference to temperature, altitude or surrounding local conditions. This instrument will be found to be very sensitive to small variations in gas value, and to be sufficiently accurate for all commercial uses.

The attention required to operate the instrument consists of keeping the sampling pump properly lubricated, which requires an inspection once or twice a day; changing dials and filling pen, which must be done once in twenty-four hours; winding the clock mechanism for driving the recorder, which must be done once every week.

This instrument, which is manufactured by the Lexington Instrument Works, Lexington, Ky., serves the same purpose in a producer plant that the combustion recorder and steam pressure gauge serve in the steam boiler plant.

CALIFORNIA PRODUCES ALL THE BORAX

California is the only State which makes a commercial production of borax annually. The output for 1910, according to the United States Geological Survey, was 42,357 short tons, valued at $1,201,842. Less than four tons was imported. About one-half of the borax consumed is used in the enameling industry for making kitchen and sanitary ware. Each year some new use is found for the mineral.

THE LATEST CATALOGUES

Searchlight Projectors for Commercial Use

Bulletin No. 4928, recently issued by the General Electric Company, is devoted to commercial searchlight projectors. This bulletin describes not only the carbon arc projectors, for which this company is noted, but contains also illustrations and description of the incandescent lamp searchlights just placed upon the market by the General Electric Company. The bulletin contains data relative to the subject which should be of great interest to yacht and motor boat owners.

Tarpet Rock Drills

Ingersoll-Rand Company, 11 Broadway, New York City. Bulletin Form 4204, sixteen 6 x 9 pages, descriptive of arc valve tappet rock drills. These drills have an arc-shaped valve, which is moved on a circular seat by a rocking tappet, the sliding surfaces all being concentric with the rocker pin. The working pressure is on the back of the valve, forcing it to its seat, so that wear, instead of inducing leakage, only improves the tightness of the working valve parts. The valve is moved by the piston through an intermediate tappet or rocker. This tappet swings on a pin and extends slightly into the cylinder bore, where it is moved by beveled shoulders on the piston sliding under it. An arm on the tappet carries a spring and plunger engaging the valve. The function of the spring is to hold the valve to its seat when there is no pressure on the drill. This arrangement of spring and plunger also acts as a relief valve in discharging water of condensation which may collect in the cylinder when steam is used.

Catalogue shows duplicate parts of drill, also sectional views, and gives descriptive table of sizes and capacities.

Stone Tools

Twenty-four-page, illustrated catalogue descriptive of the Keller stone tools manufactured by the Chicago Pneumatic Tool Company, Fisher Building, Chicago. It is claimed for these tools that they have a minimum number of working parts, the cylinder, piston and inlet piece being the only parts required, while the cause of frequent breakdowns is avoided by the absence of latch-pins, springs and plugs to get out of order. A copy may be obtained by addressing the above-mentioned company and mentioning CASSIER'S MAGAZINE.

Electric Heating and Cooking

The General Electric Company has just issued an attractive publication relative to electric heating and cooking appliances and their application to the home, office and factory. This bulletin, No. 4921, is printed in two colors on heavy coated stock, and has a very attractive embossed cover. Many of the various devices are shown in use.

The publication contains also a section devoted to wiring plans and wiring devices for the home.

"Starting Currents of Transformers, with Special Reference to Transformers with Silicon Steel Cores," by Trygve D. Yensen, has just been issued as Bulletin No. 55 of the Engineering Experiment Station of the University of Illinois.

The transformer has come to be regarded as one of the most reliable and simple pieces of electrical apparatus. As new material, however, is utilized to increase its efficiency, new problems arise. One of these problems is the momentary rush of current that occurs upon closing the primary circuit of a transformer. In

Bulletin No. 55, it is shown that, while this starting current for old-type transformers may rise as high as four times full-load current, it may rise to more than seven times full-load current for the new type with silicon steel cores. The phenomenon is fully explained and illustrated by means of oscillograms.

Copies of Bulletin No. 55 may be obtained upon application to W. F. M. Goss, Director of the Engineering Experiment Station, University of Illinois, Urbana, Ill.

Alunite in Utah--Potash-Bearing Mineral Described in Report Reissued by United States Geological Survey

Continued interest in American potash discoveries has necessitated the reprinting of practically all the recent Government publications on the subject. The United States Geological Survey has just reissued Bulletin 511, by Hoyt S. Gale, on alunite, a potash-bearing mineral found in a newly discovered deposit near Marysvale, Utah. Special interest attaches to alunite, for the potash which it carries is believed to be commercially soluble—that is, it can be reduced to fertilizing material, for instance, by a simple process of roasting and leaching the rock. The bulletin describes a vein which is believed to be of considerable size, and although it can by no means supply the American demand for potash, it may meet local needs. The commercial development of this deposit will be of greatest importance, perhaps, in stimulating exploration for other similar deposits. Alunite has been observed by other members of the Geological Survey at several points in a number of Western States, and it may, therefore, be expected that further prospecting and investigation will disclose deposits that may yield a large tonnage.

A copy of Bulletin 511 may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

The People Still Own Valuable Water-Powers

A study of Western rivers by Geological Survey engineers has developed the fact that many very great water-powers are still owned by the Government. A large number of power-site withdrawals have been made by the President on the recommendation of the Geological Survey since May, 1909, when the first of these recommendations was made. The power-site withdrawals now outstanding aggregate 1,747,522 acres, distributed along the important power streams of the Western States. Reservoir withdrawals have also been made to the extent of 94,908 acres.

Probably Increased Production in 1912

The Survey's estimate on January 2, 1912, indicates a copper output for 1911 greater than that of 1910 and nearly equal to the record production of 1909. It is further stated that most of the companies are now in a position to maintain or even increase their present output, so that, if the consumption of the metal will permit, the production of copper in the United States for 1912 may be expected to show a marked increase. It is noteworthy that not one of the leading copper districts of the United States, several of which have been active producers for thirty years or more, has been worked out or shown a decrease in its ability to produce copper.

Lack of Tin Deposits in the United States

Tin is one of the minerals in workable deposits of which the United States is lacking. Our production in 1910 was valued at only $23,447, according to the United States Geological Survey, while our importations were worth $33,913,255. We need one or two large tin mines.

PERSONALS

On the evening of April 30 last the American Society of Mechanical Engineers conferred honorary membership in the Society to Rudolph Diesel, D. E., D. Sc., Director Verein Deutscher Ingenieure, inventor of the Diesel engine.

The same evening Dr. Diesel delivered an illustrated address on the development of the Diesel engine.

Mr. H. F. J. Porter, who has taken a most active part in the organization of the Efficiency Society, and who served as acting secretary during the preliminary work, has been elected secretary of that Society.

The temporary office of the secretary will be in the Engineering Building, 29 West Thirty-ninth street, New York, N. Y.

Mr. E. E. Lake, who has recently conducted a consulting metallurgical business, and who was formerly steel editor of the *American Machinist,* has been placed in charge of the laboratory of the Perfection Spring Company, of Cleveland, Ohio.

The J. Faessler Manufacturing Company, Moberly, Mo., makers of Boss and Universal Flue Expanders, Flue Cutters and other boiler tools, have reorganized their sales department and placed Mrs. Charles F. Palmer in charge as sales manager, with office at 810 Olive street, St. Louis. Mr. Palmer is well qualified for this position through previous experience in selling Faessler tools and as representative of the Frank E. Palmer Supply Company, of St. Louis.

The Davis-Bournonville Company has been appointed the exclusive selling agent for the Davis-Bournonville Acetylene Development Company and The National Pneumatic Company. The Eastern department of the Davis-Bournonville Company will be at 90 West street, New York, their present quarters, while the Western Department will have its offices at 515 Laflin street, Chicago.

During the week of October 7-11, 1912, a convention will be held at Chicago, Ill., by the American Electric Railway Association. The meetings will be held in Home of the Saddle and Sirloin Club, while an exhibition will be held in the Dexter pavilion. Mr. H. C. Donecher, secretary of the association, states that present indications are that this convention will, in point of attendance, far excel that of any previous year.

The Penberthy Automatic Cellar Drainer

(Concluded from page 84.)

H, which is so constructed that, instead of the water being drawn directly upward, it is taken in at the sides, allowing all sediment to collect under the strainer without being disturbed by the force of the suction. A foot valve is also provided inside the strainer, which closes the instant the drainer ceases operating, holding all water in the pipes, all primed for starting instantly at the next filling of the sump.

The Penberthy automatic cellar drainer is particularly adapted for use in pits, sumps, cellars, tanks, settling basins, or wherever it is desired to keep water or other liquids from going above a certain level. It is more efficient, takes up less room, will last much longer, and sells at a lower price than asked for many drainers not as efficient. They are made of best bronze metal, except the float, which is copper, and can be regulated for any water pressure.

CONSTRUCTIVE AND RECONSTRUCTIVE INFLUENCES OF THE AUTOMOBILE

By Melville G. Crafts

THE development of the automobile and its constantly growing use have had a much larger influence on many industries than is apparent at first thought. The drop-forge business has been greatly increased through the development of the modern automobile, while, on the other hand, the automobile as we know it to-day would be hardly possible without the high grade of efficiency to which drop-forging has been brought in the effort to keep up with the demands of the automobile manufacturers. The present high efficiency of the internal-combustion engine is directly traceable to the automobile. The enlarged use of and the improvement in the manufacture of rubber come from the demand for satisfactory automobile tires; the improvement in the art of steel making, in automatic machinery for manufacture, and in more lines than space allows enumeration, show, directly or indirectly, the influence of the demand for automobiles on their expansion and improvement.

In the last few years the automobile, as its use has developed in the United States and all other countries, has given the improvement of the condition of roads and highways an impetus which has never been equaled, or, for that matter, approached, in the history of highways. Before the day of the locomotive the highways of a country were everything, the very arteries of civilization and development; but with the advent of the locomotive the highways, though still important, fell into a secondary place, and only came into their own again with the perfection of the automobile. In the days of stage coach travel much attention was given to them, but as the growth of travel by "roads of steel" progressed the highways were used only for short-distance travel, and as their importance decreased, so did their condition.

The United States never possessed a system of highways equal to that of many other countries; for though as the agricultural importance and the mechanical and industrial products increased a gradual improvement in the roads took place, yet the invention of the steam locomotive and the development of the rail transportation in a comparatively early stage of the growth of the United States checked the construction of highways, our roads being used, for the most part, for short distances, as between the farms, the factories and the railroad stations.

During the period of travel by stage the business and importance of the country inns were no mean ones; the railroads changed this, however, and the inn or hotel situated any great distance from direct railroad communication ceased to exist, unless it possessed the advantage of some remarkable attraction in the way of natural scenery or other cause that changed it into a resort for pleasure or health-seekers.

The wide use of the automobile, which has made many people to a large extent free of the railroads for travel, has changed the condition once more, and the importance of the hotel or inn away from direct rail communication and off our railways is increasing each year, while such houses as in former years depended largely for their patronage

on persons who came by rail and spent a more or less extended period now find that, in addition to such guests, provision must be made for the transient guests constantly arriving and departing by automobile.

A few years ago one never thought of going from New York to Montreal, for example, except by train, while to-day undoubtedly one of the most widely used highways in the East is that between these two cities, a large portion of which is along State roads, going up along the east side of the Hudson river (although the west side can now be used as well and with equal satisfaction), passing through Albany, and, via Schenectady or Mechanicsville, to Saratoga Springs, Glens Falls and Lake George, at which point the new all-year-round resort hotel, the Fort William Henry, is located. This location emphasizes the statement made above, first reached by hunter's trail or by canoe or boat on the lake, later by stage coach, and still later again by the railroad, and now not only reached by rail, but by a constantly increasing number of highways, due to the development of the automobile.

The trip can then be continued from Lake George to Schroon Lake, when, if desired, a detour can be made in order to travel along the picturesque shore of Lake Champlain, going easterly to Fort Ticonderoga, up to Crown Point, where stands the imposing Champlain Memorial Lighthouse, at the base of which stands "La France," the Rodin bust recently presented to the nation by the French Republic. From this point the lake shore trip may be continued or one may turn west at Westport and proceed inland to Elizabethtown, which is a more direct route. From Elizabethtown a main road launches off westerly to Saranac Lake and Lake Placid; northerly to Keesville and Peru, passing Bluff Point, where is located the Hotel Champlain. This hotel again illustrates the influence of the automobile, as it opened as early as June 15 this season, in order to accommodate the early tourists. From this point it is a two-mile run to Plattsburg, where the trail continues on up to Rouses Point, Montreal and Quebec.

In fact, so important has the custom of motorists become, from whom they derive such a large volume of business each year, that the leading hotel men throughout the State of New York have formed the Empire Tours Association, the trails of which are characteristically named Adirondack, Iroquois and Onondaga.

Through an interchange of courtesies, the hotel men keep each other posted regarding the conditions of roads and other matters of interest to automobilists, and it is now as essential for their clerks to be able to give information concerning trails, running directions, road conditions, supply stations, etc., etc., as to know the train and mail schedules.

If a hotel clerk was asked only a few years ago what was the best road to take between almost any cities, he could probably only answer with any degree of truth, "the railroad," as it would never enter his head that people would travel any other way, nor could he have directed them if they had; but now all this is changed and the automobile is the factor that has accomplished it.

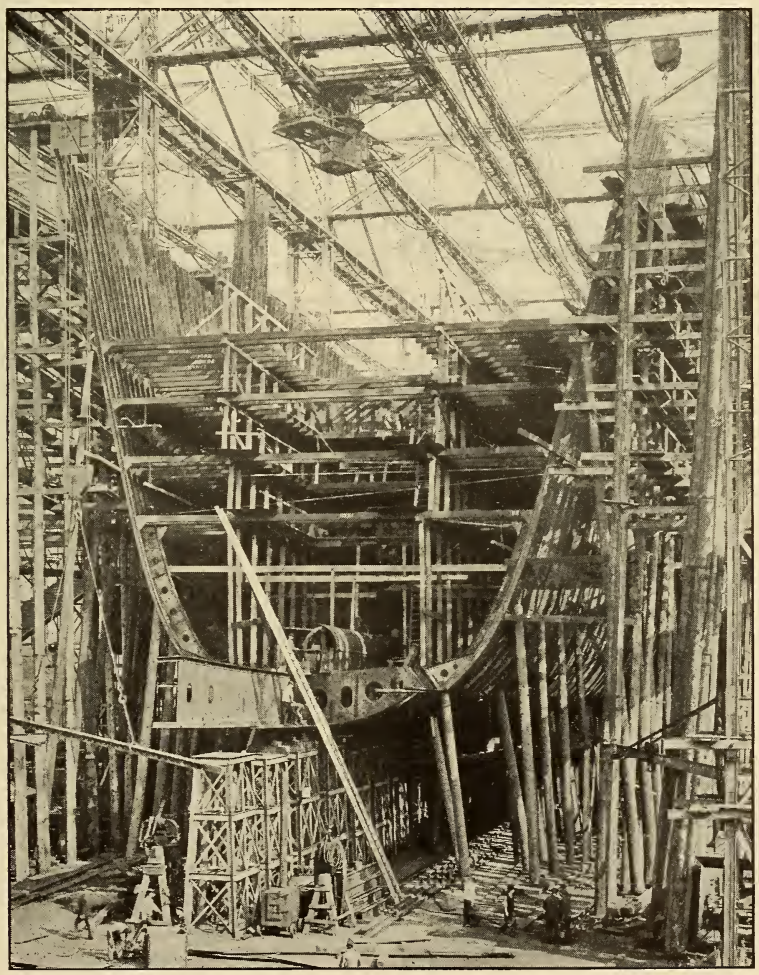
This is but one example of the changes the development of the automobile has caused, only one of the effects it has had—effects that have left their mark in so many directions and done so much to enlarge business in so many lines, as well as to afford convenient and useful transportation for both mankind and many of the articles that mankind demands and requires.

The automobile, both the pleasure car and the commercial truck, is working changes fully as remarkable as the locomotive, and is doing much to add to the health and happiness of the people of the world, while as an industry its development has brought increased work and profit to vast numbers in many lines of effort.

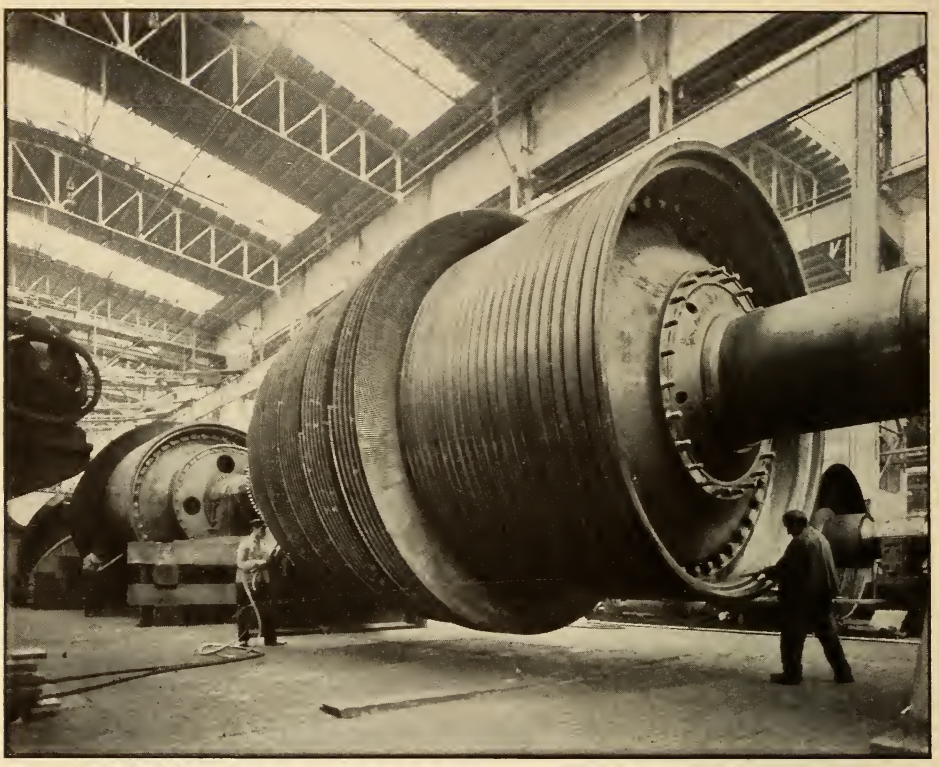
CONSTRUCTION OF S. S. IMPERATOR

By M. B. Cea

ALTHOUGH the launching of the steamship *Imperator* attracted world-wide attention because of its great size, the importance of the great vessel in the development of shipbuilding is due more especially to the perfection of its construction and completeness of equipment. The new ship exceeds all other ships afloat in every dimension. With her length of 900 feet, a 96-foot beam and her nine clear



HAMBURG-AMERICAN LINE STEAMSHIP "IMPERATOR," SHOWING SIZE OF TUNNEL RUNNING ABOVE HER KEEL AS WELL AS THE DOUBLE BOTTOM



SECTION OF TURBINE. S. S. IMPERATOR

decks above the water line, she is readily the largest ship in the world and one of the largest construction ever attempted. Her enormous size has made possible many methods of construction never before employed. The cabins of the *Imperator* are the largest and most luxurious afloat, but there has been found in this enormous hull ample space for the most elaborate safety devices as well.

The ship has been built with a complete double bottom extending her entire length. The space between the two steel hulls is high enough to permit a man to walk without stooping from one end of the hull to the other. This second hull gives the great ship a complete double skin throughout her great length. In other words, she is a ship within a ship. An accident however serious, it is believed, to the outer hull would leave the inner skin of the ship intact.

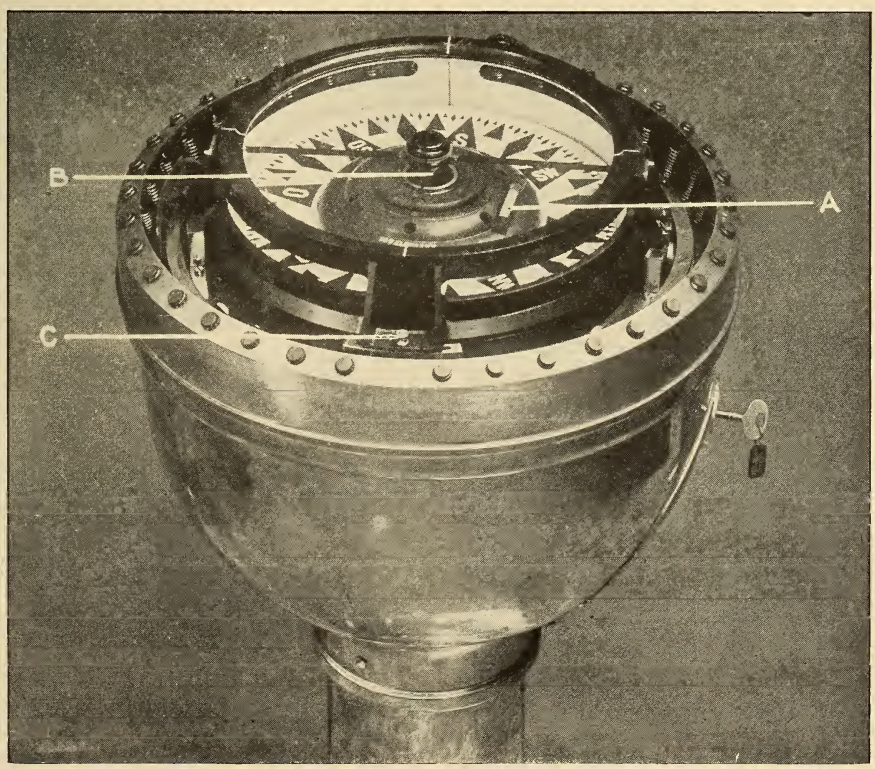
The speed of the new liner, again, will not be sacrificed to safety. The *Imperator* will be driven by Parsons turbine engines, which will propel the ship at an average speed of 22½ knots. These turbines have attracted great attention because of their great size and the relative delicacy of their construction. One of the immense rotors contains 50,000 blades and weighs 135 tons, and is capable of developing 22,000 horse-power. The casing enclosing the rotors is 25 feet long by 18 feet wide. The shafts are 1½ feet in diameter and the four-blade propellers, which are of Turbadium bronze, are 16 feet in diameter. All the castings and materials employed in the construction of the machinery have been subjected to hydraulic pressure tests to determine their strength.

The *Imperator* is provided with bulkheads which extend both transversely and longitudinally. The ves-

sel is divided into numerous water-tight compartments, thus insuring safety should two or more adjacent compartments be filled with water. The bulkheads are of exceptional strength and height. She has twelve transverse bulkheads and one longitudinal bulkhead in her engine room. These bulkheads extend from the bottom upward for 50 feet, reaching to the second deck, far above the water line. There is a forward or collision bulkhead extending through the first deck. The braces supporting these vary in weight from 2,200 to 9,900 pounds. The single bulkhead amidship alone weighs 66 tons.

These bulkheads are provided with some 36 water-tight doors fitted with an automatic closing system, which is operated by electric and pneumatic power. There are loud speaking telephones between the various navigating and engine departments of the ship. As a further precaution electric annunciators will be established enabling the officers to ascertain whether their orders have been received and carried out. As an additional precaution the very latest practical nautical instruments will be used, notably the gyroscopic compass, described fully in the October, 1911, number of this magazine, which is unaffected by magnetic disturbances. The ship will also have submarine signals which will notify it on approaching harbors and dangerous points. The wireless apparatus on the *Imperator* will be the most powerful ever installed on shipboard, enabling her to communicate with other ships and wireless stations throughout an enormous area.

(Concluded on page 84.)



GYROSCOPIC COMPASS, WITH TOP COVER REMOVED

A, level; B, central stem; C, clamp screw for lubber point

Metal for Journal Bearings

THE old idea in the design of bearings for shafting and machine journals was that of a bored hole in hard bronze or cast iron, fitting very truly the revolving portion to be placed in it and held firmly and closely in position. Theoretically, this was entirely correct, and in practice it was also correct, so long as the implied conditions were maintained. In practice, however, it was found that other conditions existed, conditions which insisted upon being considered, and the result was the invention, many years ago, of the so-called Babbitted bearing. The invention of Mr. Babbitt was not, as is so often believed, that of a special kind of soft bearing metal; it was far broader and more important, since it included the use of what he termed a "hollow box," or cored space around the bearing in which the journal was to revolve, this space being filled in by pouring in a soft melted metal, either about the actual journal to be run at that point, or, preferably, about a standard size mandrel, permitting the bearings to be scraped to fit the journal.

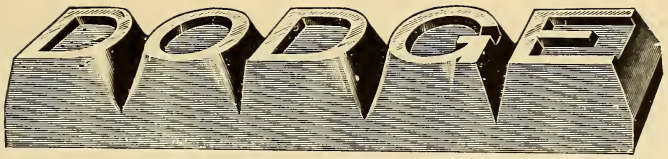
This method was especially adapted for the period in which it was developed, when many workshops were unfitted to bore out solid bearings with the precision which such work demanded, and it has always been found desirable for use in machinery which is destined for use at points distant from repair shops, where worn and cut bearings demand attention immediately with such facilities as are close at hand.

Under such conditions the hollow box filled with soft metal came into general use, and it has been found that, when properly employed, this form of bearing is better adapted than almost any other kind for practical service, both in the shop and elsewhere.

The main thing demanded by a bearing lined with special metal appears in the kind of metal with which it is filled, since this it is which is in contact with the journal and upon which the wear and service fall. Naturally, the metal used for pouring in a journal box varies according to the character of service demanded. In some cases the speed is high and the pressure moderate, while in other instances the greater unit pressure demands a harder and more resistant material.

The various mixtures bearing the name of "Babbitt" have grown up since the invention of the hollow box, and some of them doubtless had the sanction of the mechanic whose name they bear for certain purposes and conditions. Modern engineering and metallurgical practice, however, have produced alloys adapted for nearly every kind of service, and it is always wise to be guided by the experience of competent engineers who have encountered the various cases.

The experience which has been gained during recent years in the admixture and the physical and thermal properties of metallic alloys has enabled the modern transmission engineer to prepare, for use in the journal boxes of shafting and machine members, such materials as enable the greatest wearing capacity to be united with ease of operating a minimum of friction and generation of heat. It is well understood that one of the sources of waste of power and reduction of efficiency in power transmission lies in the absorption of power in the overcoming of frictional resistance and the generation of undesired heat. Some bearing designs are so arranged as to provide for the conduction of heat away, either through ample masses of metal or by flooding with a circulation of oil or water. Such arrangements may be wisely provided to avoid injurious heating, but the demands of efficiency would indicate that the better plan would be the use of such bearing metal as would insure cool running under the actual operative conditions, thus rendering it unnecessary to carry heat away by the simple expedient of not producing any.



BEARING METAL

As manufacturers of the Dodge Line of Shaft Hangers and Bearings, we have for years been perhaps the largest users of bearing metals in the country.

We have experimented with all sorts of bearing metal alloys and have learned considerable about them.

Some years ago we adopted as our standard, a bearing metal which we had discovered to be the best for 90 per cent. of all mill and factory requirements.

This Metal has been tried and tested under many conditions

It runs cool and wears long in more different situations than any other alloy we ever used.

We think enough of it to cast the bar in the shape of the name DODGE and back it up with our reputation.

DODGE Bearing Metal is carried in stock by dealers and branches everywhere, and the price is twenty-five cents per pound.

It is packed 50 pounds to the box.

On initial orders of 100 pounds we allow the freight.

If you are unable to obtain it, write us direct or the nearest branch, and we will fill your requirements promptly.

DODGE MANUFACTURING CO.

Everything for the Mechanical Transmission of Power

Offices and Factory, Mishawaka, Indiana

Branches and Warehouses

New York	Minneapolis	Boston	Cincinnati	Chicago
21 Murray Street	202-204 Third St., South	137-139 Purchase St.	126-128 West Third St.	208-214 South Clinton St.
St. Louis	**Pittsburgh**		**Philadelphia**	**Atlanta**
507 North Main St.	337 Second Avenue		815 Arch Street	54-60 Marietta St.

AGENCIES IN OTHER LEADING TRADE CENTERS

The Scientific Management of the Rock Drill

IF we have in these days any considerable job of rock cutting or of rock excavation anywhere, the most responsible and necessary item of the apparatus employed is the power-driven—air, steam or electric-air—rock drill. Since its advent more rock has been removed from its native beds than in all the years of civilization before that, and the rate of rock removal and the quantities of rock to be removed increase with the years. The strenuous task of the drills and its rapid accomplishment have reacted upon its concomitants; it stirs all associated with it to a general hustle and still keeps itself ahead.

While the rock drill has been constantly developing into increased efficiency, the associated means connected with the handling of the materials liberated by it have not been able to keep pace with it. We might, naturally, have expected, as the drilling of the rock was the initiative operation and that which alone made all the other work possible, that the drill would be occupied most or all of the time; but really the drill has lots of standing around and waiting to do, hoists and cars and conveyors being employed more constantly. In the best records of tunnel driving that we have—say those of the Loetschberg tunnel—the actual working time for the drills was only two hours for each eight-hour shift. The drills, so far from holding back all the rest of the work, have really become the pacemakers.

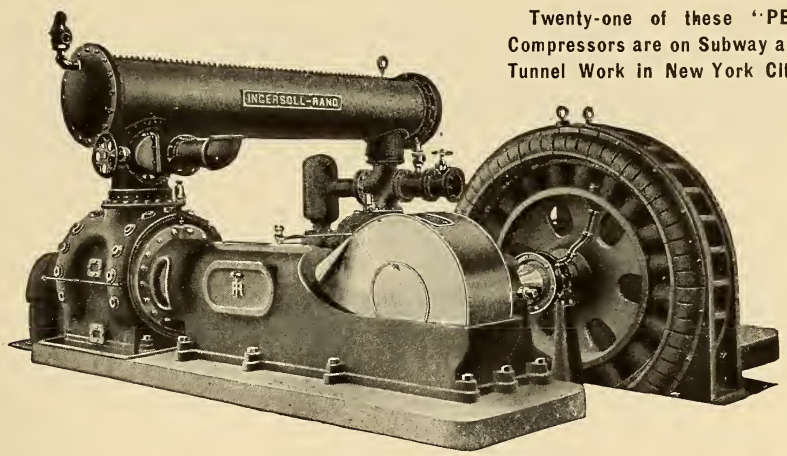
The fact is, that what is now exploited as "scientific management," "motion study," "specialization of function," and the rest of it, were being developed, stimulated, promoted by the rock drill before these recent loud catchwords were thought of.

The drill itself has been improved in every detail and developed into types showing little relationship in design or in principle of operation to its earlier progenitor. The means of holding the drill securely when at work, so that it can be set quickly and fastened firmly and precisely and be pulled down and removed and brought forward and placed again by the average mine worker without balk or delay, have been brought to great perfection. Then the selection of the bits and their maintenance have been given equal study; and the distribution and angle and depth and size of the holes, varying according to the dimensions and scope of the work, the hardness of the rock, the pitch of the strata, have all demanded special consideration.

The determining of the best explosive for each special case, the size of the charges to be used to best throw or to most completely shatter the rock, the sequence and manner of firing of the several shots, constitute another line of responsibility only to be satisfied by experience.

After the explosion in mine or tunnel the ventilation expert has his task. This is, first, to so remove or dilute the gas-laden air that men will be able to resume operations at the face, and then follows the general problem of ventilation, of so maintaining a standard of purity for the air that the health of all the workers will not be seriously affected. This is the subject of unending legal enactment, and no man knows what should be known upon this topic.

And all this is only preliminary to the final work which the rock drill stands for—the getting and the removing of material, some of it merely to get it out of the way by dumping it in some other place, much of it to be used in various ways; from quarries for building or monumental purposes, from mines for its intrinsic values. In all cases the most onerous actual work, requiring the most power and taking the most time, is the hoisting and conveying of material. In this work of detailed transportation at the beginning and of general transportation farther along is the life-work of great engineers.



Twenty-one of these "PE" Compressors are on Subway and Tunnel Work in New York City.

Four Years of Continuous Operation, and Not a Dollar for Repairs

A 22-inch stroke Class "PE-2" Direct-Connected Motor-Driven Compressor, of the type here illustrated, has been running for four years at the Yampa Mine, Bingham, Utah, without one dollar of expense for repairs.

Can there be any more conclusive evidence of the durability and reliability of Ingersoll-Rand Air Compressors?

The "PE" Compressor is only one of the twenty standard Ingersoll-Rand Compressor types, throughout which runs one uniform quality of design, workmanship and materials.

Capacities in these types range from 8 to 8,000 cubic feet per minute, for pressures of 5 to 3,000 pounds. **We can meet your conditions exactly**—in steam, power or electric driven units.

When you buy an Ingersoll-Rand Compressor, you buy also security against breakdown, delay and loss.

NEW YORK **INGERSOLL-RAND CO.** LONDON

Offices in All Principal Cities of the World

COMPRESSORS ROCK DRILLS COAL CUTTERS PNEUMATIC TOOLS

Modern Steel Cutting

THERE is an old saying that "the proof of the pudding is the eating," and this homely proverb, expressed in various ways, may be applied to many things besides edibles. Engineers make computations, diagrams, analyses, and other investigations, but whenever possible they endeavor to substantiate the theoretical or academic work by actual physical test. They are entirely right in using the theories of science to guide them in their plans and operations; without such methods the whole practice of engineering would be nothing but a continual operation of "cut and try," and we should be altogether dependent upon empirical rules, but after the course of operations has been laid out, or the details of a process determined, it is most desirable to verify the correctness of the ideas by a practical and severe test.

An excellent example of the manner in which such a line of action confirms the result of previous work appears in the conduct of the process for infusing carbon and other materials into soft steel for the purpose of converting the metal into high-grade tool steel at the cutting portions. It is well known that one of the principal elements of cost in making machine tools, such as milling cutters and the like, apart from the high price of the original tool steel, lies in the expense of machining and the possibilities of loss by cracking or warping in subsequent hardening. The possibility of putting the hardness on the tool, so to speak, or rather of putting the hardness *into* the desired portions of the tool, after all the machining operations have been completed, removes entirely these elements of cost. Much cheaper material may be purchased in the first place, much less cost incurred in turning, forming and cutting the soft steel, while the operation of infusing is unattended with risks of spoiling the tool after the cost of making it has been expended.

But "the proof of the pudding is the eating," and while all that has been said is undoubtedly true, the ordeal of practical test is required to demonstrate whether a cutting tool thus prepared by infusion from cheap, low-grade steel is really as good as the more expensive one in which tool steel of the highest quality has been used.

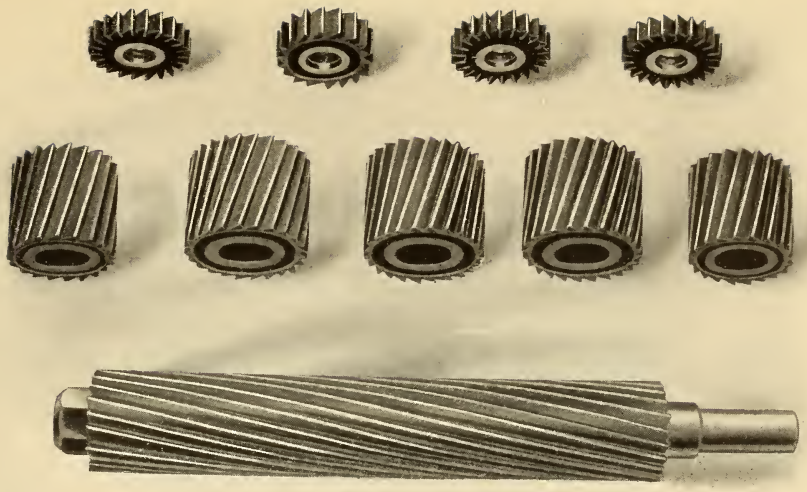
The data and results of a recent test may serve to answer these questions.

From a piece of open-hearth steel containing a very small amount of vanadium and chromium and running no higher than 0.10 to 0.12 carbon there was made a milling cutter for side milling work. The original material was what is termed type "N" steel, made in the open-hearth furnace in lots of 50 tons and sold at 5 cents a pound by the United Steel Company, of New York. This steel was too low in carbon to harden when quenched.

After being completely formed this cutter was treated by the infusion process and then put in the milling machine and set to work cutting upon a piece of normal, unannealed steel. The cut was ⅛ inch deep and the cross-feed speed 10.88 inches per minute, each cut being made the full length of the piece, 6⅜ inches.

Starting with a lineal speed of 85 feet per minute, the speed was increased five successive times, finally reaching a speed of 278 feet per minute, under which remarkable speed the cutter continued to operate perfectly, not having been removed from the machine or sharpened during the test. The test was limited, not by the tool, but because the pulling capacity of the milling machine belt was reached, while the high rotative speed of the cutter caused the oil to fly off by centrifugal force.

Such a test indicates most emphatically that the edge, infused into soft steel, is of the highest cutting capacity, while the advantage of the soft body to the tool doubtless aids in its resistance to injury.



PHOTOGRAPH OF MILLING CUTTERS TESTED BY BUREAU OF ORDNANCE
SEND FOR COPY OF THEIR REPORT ON THIS CUTTER

Milling-Cutters made from Open Hearth Steel

(costing 1½ cts. to 6 cts. per lb.) and

"infused with Stelpro"

You simply "cannot compete" (if you buy tool steel) with the fellow who buys low carbon Open Hearth Steel, MACHINES IT WHILE SOFT AND INFUSES WITH

"Stelpro"

(Class "A" for tools)

READ OPPOSITE PAGE FOR TESTS

American Infusion Steel Process Company

60 BROADWAY, NEW YORK, N. Y.

WINTER GROWN CABBAGE

THE THREE-CROP COUNTRY

By William J. Speed

THE cry of "Back to the land" is all right as far as it goes, but it is a good plan for those who think of heeding it to look with care into the land, that is, the particular portion of land they are thinking of going back to, and to remember that to win success from an unpromising outlook is a constant struggle.

Ceaseless thought and work are the prices paid for great achievements, and often the achievement of success is due to advance thought and careful planning.

In purchasing land much attention should be given to its location and suitability for the purpose it is bought for. This holds true, no matter if the purchase is made as an investment or to raise crops on. In the latter case one wants to be satisfied that it is a growing section, or rather a section where crops grow with certainty, and where one does not have to save and slave during a short summer to keep from starving through a long, cruel winter.

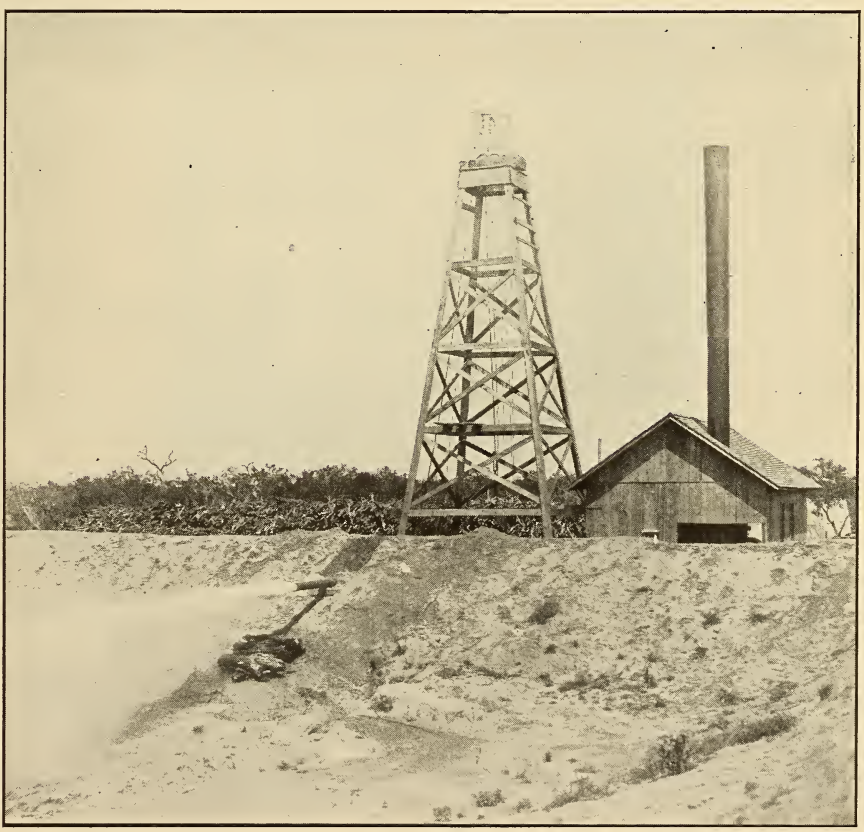
Certain crops, too, are far more profitable than others, and if a location can be found where one does not have to plant what one *must* but what one wants and knows to be profitable, that location possesses great advantages and in itself argues much for success.

Certain portions of the great State of Texas, a State so large that if it were swung over the map of the United States to the northward it would touch the Great Lakes; to the eastward reach the Atlantic; westward, the Pacific and southward the Caribbean Sea, are attracting great attention at present on account of their natural advantages both of climate and soil. The State of Texas is first in size, first in agriculture and first in live stock. Her farmers annually market crops to the value of $561,339,000, and there are 30,000,-

000 acres of land under cultivation; and she raises three quarters of a bale of cotton per capita for each of her 4,000,000 people.

The field crops of Texas are cotton, corn, wheat, oats, alfalfa, rice, potatoes, tobacco, sugar cane and forages, while her fruits include peaches, apples, pears, berries, figs and citron fruits of all kinds, and in certain sections, for instance the Rio Grande Valley, crop failures are unknown, and, what is more, three or four crops can be raised each year from the same land without the use of fertilizer. In fact, in many parts of the Rio Grande Valley there are farms that have been large producers for a hundred years that have never had an ounce of fertilizer on them. These farms are good for another hundred years without fertilizer, because the top soil is from ten to fifty feet deep.

Texas is fast becoming the kitchen garden of the United States. The increase in the truck and fresh fruit industry has been wonderful in the last year, it having expanded at such a rate that the railroads have had trouble in providing sufficient refrigerator cars to keep pace with it. Never before in the history of the railroad business in Texas has there been such a demand for refrigerator cars as exists of late in different parts of the State; in fact, the transportation facilities of several Texas roads have been taxed, though there has been no serious shortage of cars to affect the movement of vegetables and truck.



ARTESIAN WELL SUPPLYING WATER FOR 160 ACRES

The season opened the first of April with a record-breaking production of cabbage, hundred of cars being shipped from Texas points. This was followed by the Bermuda onion movement, which promises to aggregate 4,000 cars. In addition to these hundreds of cars of other vegetables, lettuce, cauliflower, radishes and snap-beans were handled by the railroads during May.

A conservative estimate by railroad traffic men in Texas places the total movement of vegetables and fruit in that State for the year 1912 at upwards of 30,000 cars; and when the fact is considered that all of this traffic is comparatively new business, it speaks most effectively of the development that is going on in the State of Texas, as only a few years ago the railroads did not take into consideration the few carload shipments of fruits and vegetables they handled out of Texas, while at present such shipments form a very important feature of the railroad tonnage of that State.

The production of vegetables and the shipment of them along the line of the "Frisco" system this spring have been more than double what they were during the same season last year. In fact, the truck growing industry of Texas is increasing by leaps and bounds, and the railroads are encouraging it in every possible way.

One of the most fertile tracts in the entire Southwest is La Jara, situated in Hildago County, in the Rio Grande Valley.

The La Jara farms are in the famous Artesian Belt and artesian water is secured at a depth varying from 500 to 1,200 feet and at a cost of from $1,000 to $2,000, depending on the depth and size of the well. This water is absolutely pure, being drawn from subterranean streams formed in the water sheds of the Rocky Mountains, thus affording a continuous and inexhaustible supply.

Irrigation, however, is not necessary, as in this section there is an average natural rainfall of about twenty-eight inches, which is distributed over every month of the year. It has been found, however, by practical experience that because of the tremendous increase in production the cost of irrigation is the best investment the farmer can make.

As to health and climate, statistics show one birth in Texas every four minutes, while there is a death only every twelve minutes; more need not be stated.

FIELD-GROWN WINTER VEGETABLES

PICKING ONIONS

Texas is not only a land of promise but a land that fulfills its promises and a land of opportunity for even the inexperienced. The opportunity for independence in a section where the crops grow every month in the year is attracting a large number of conservative people who plan to establish their homes in the Lone Star State.

When it is remembered that even with their crude methods the original Mexican tenants of La Jara have been able to farm successfully for upwards of sixty years, one can easily comprehend what the development of this section is to be under the improved conditions and methods now forging to the front there, and why, as economic writers agree, the immigration now going forward to the Rio Grande Valley is the greatest movement that has ever taken place in America.

An important factor in the development of land, replacing the shortage of labor and increasing the output, is found in the employment of the traction engine, using oil for fuel, and doing the work of both men and horses. One of the best-known machines of this kind is the so-called "Oil-Pull," made by the M. Rumely Company, of La Porte, Indiana, and, in a country such as Texas, in which fuel oil is available, this machine aids materially in the solution of the labor problem.

It should also be remembered that at present the movement is in its infancy, and that this movement is constantly increasing land values, so that purchasers who do not cultivate their land yet obtain the benefit of increased value due to the improvement of surrounding lands, which is the reason many are investing in Texas land, realizing that as a locality becomes a center of human interest and activity land values increase enormously and a tract worth but $100 per acre for pasture jumps to the thousands as a business center or as a home site.

The present tendency toward the purchase of Texas lands is due to the definite knowledge concerning them possessed by a large number that such purchase is "good business," as lands in that State are rapidly increasing in value and are certain to prove a most valuable investment.

OUR PROPOSITION AND YOUR OPPORTUNITY

The Beautiful Rio Grande River

Land as Rich as the Valley of the Nile

YOU can burn less fuel, swallow less medicine, wear less heavy clothing and save money easier in Texas than elsewhere in the world. You can plant something and harvest something three hundred and sixty-five days in the year. You can raise practically everything raised in every State in our country, and in every country on earth. You can raise three and four crops of vegetables in succession—on the same ground—in the same year.

Our Booklet, Sent Free, Tells The Story

Insure Your Future Against Want

MOST men have a longing to become millionaires. It seems to be a popular idea that happiness and contentment can be associated only with unlimited wealth. There is no doubt we should be considered benefactors of our race if we could tell our fellow mortals how to become wealthy. We make no such claim and have no such power.

The man or woman who would possess a fair supply of this world's goods, must first learn to spend less than they earn, then learn how to put their saved dollars to work for them. No man ever got rich by the 3% route. It is also well understood that no one gets rich by hoarding money.

A few men have gone to bed poor at night and were rich when they got up in the morning. These cases, however, are few and far between. There is no quick and easy way of getting rich.

Courage and energy count. The more intelligence a man has, the greater his earning capacity. The laborer plowing a field works harder and longer than does the ranch superintendent, who receives ten times, or possibly one hundred times more salary.

The Rio Grande Valley

the land of realization for the man of limited capital

The Land of Promise

that fulfils its promises

Nine Weeks' Growth of Corn

12,000 Acres in a Three Crop Country

THIS Company owns over 12,000 acres of land in Hidalgo County, known as La Jara Farms, in the Rio Grande Valley of Texas. The project has so many remarkable features that it is impossible to cover them all.

The Rio Grande Valley Company

334 FIFTH AVENUE

New York

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WE will deliver to you a forty-acre farm within easy distance of railroad, churches, schools and business houses—all good, productive, level land—providing you pay 10% down and a few dollars a month.

When payments are completed you receive a deed to the forty acres, which should produce an income of from $2,000 to $20,000 a year. $20,000 is equal to 5% interest on $400,000. Prices are subject to advance without notice.

If you cannot go to Texas to select your own farm we will allot you a plot best suited to your wishes. You may have three months in which to personally inspect your farm, or make investigation. If, for any reason, you are dissatisfied we will exchange your farm for any other unsold tract.

Any time you choose to complete your payments a discount will be allowed from the amount still due. You are not spending money when you invest it in fertile land like this—you are merely changing the location of your funds—and in its new location it should yield larger returns.

A Profitable Field of Cotton

Crop Failures Are Unknown in the

Rio Grande Valley, Texas

A Valley Located
Where frost is not to be feared
Where three or four crops a year
may be raised on the same land

A Land of Opportunity

for even the inexperienced

The Rio Grande Valley Company
334 FIFTH AVENUE
New York

WRITE FOR OUR CIRCULAR

IT is a plain circular, a plain statement of facts told in a plain way, telling a true story, which will appeal directly to you and will show you how a few dollars securely invested in a Rio Grande Valley Farm will net an assured income of from $2,000 to $20,000 each year.

The circular contains much valuable information concerning

TEXAS

THE THREE CROP COUNTRY

where FORTY ACRES mean

INDEPENDENCE

Strawberries in Mid-Winter

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THE professional man and the business man have the necessary educational equipment and the practical experience to understand the conditions governing the judicious investment of money.

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FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

OF THE
INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

THERE has been noticeable in most lines of trade during the past month a certain repression, rather than depression. Many important transactions have "hung fire" without apparent cause. However, the business situation, on the whole, is encouraging, and maintains its recent favourable aspect.

Optimistic advices continue to come in from the iron and steel centres. It is authoritatively stated that large steel plants are operating almost at their full capacity, and continued activity is expected during the summer months.

Railroads during the early part of May showed a substantial increase. The copper market is decidedly firm and manifests an upward tendency. Mercantile lines generally reflect increased strength and confidence. However, trade in the dry goods line has been somewhat affected by the unseasonable weather. Our foreign trade continues splendid, and bids fair to reach record-breaking proportions before the end of the year.

The recent report of more than 7,000 National Banks to the Comptroller of the Currency indicates increased commercial activity, and, with the exception of the stock market, the financial situation is fairly satisfactory.

The professional trader, with a persistency and determination worthy of a better purpose, has fought without success to stimulate interest in the speculative side of the market and again get the public on the trading list.

It is regretable that the notion prevails among so many otherwise shrewd individuals that the public is gullible. The facts are the public has progressed very rapidly in matters pertaining to finance, and while a few investors insist upon playing with fire, a great majority refuse to be drawn into a speculative, marginal campaign, the very object of which is, always has been, and always will be, to enrich the insider at the expense of the investor.

Many charge the inactivity of the stock market to a feeling of timidity inspired by the unusual political conditions. We do not agree with this view. In our judgment, people are engrossed with, rather than alarmed at, the present political situation. We have little patience with those individuals who prophesy disaster simply because there is manifested a strong desire on the part of the rank and file of voters to apply to present-day conditions practical methods of government.

There is nothing in the affairs of men, especially when it pertains to

Appeals Directly to the Substantial Business Man

FINANCIAL AMERICA

"A thoroughly practical newspaper, a publication of, by and for business. It is one of the two most influential business periodicals in the Nation to-day."
—The Leader, Richmond. Va.

Prints a table showing relative worth compared with stock market prices, a complete analysis of the leading issues listed on the Stock Exchanges of the country, a concrete showing of actual conditions.

Thousands of pages have appeared in other publications in vain effort to reach facts here presented in form that the variest tyro can understand and appreciate.

News-Gathering Facilities Unequalled
Editorial Strength Universally Conceded

The editorial policy of the paper, like its news service, is entirely unfettered. The paper has no axes to grind. All questions of public interest are handled with absolute indifference as to the opinion of financial or political magnates.

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40 Stone Street **New York**

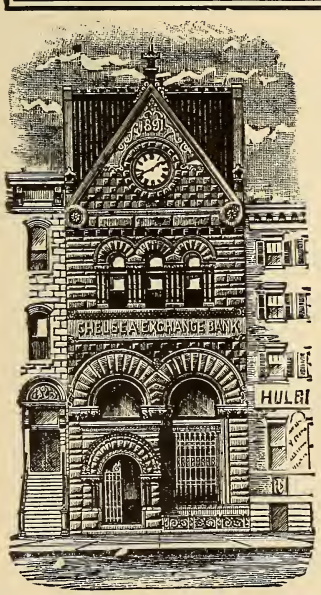
government, that is more difficult to overcome than a custom so long established that it has become petrified by honest but misguided prejudice, and adhered to either because of fear of the consequences of a change or because the continuance of such a custom enables specially privileged individuals to conceal their real motives under the guise of conservatism. For the first-named unfortunates we have nothing but compassion, while the latter we pity because of their depravity and self-inflicted blindness, which prevents them from recognizing that the law of progress is absolute and ever-active, and it is not within the power of any one man, or body of men, to stop its operation.

The twenty-first annual report of the directors of the Philadelphia Bourse, which was submitted to the shareholders in May last, shows that it is in a most flourishing condition. The revenue from room rentals from exhibition spaces shows an increase over that of last year. The board of directors and Mr. Emil P. Albrecht, secretary and treasurer, are to be congratulated on the important work the Philadelphia Bourse is accomplishing.

Question—What is your opinion of Bethlehem steel preferred?

Answer—The Bethlehem Steel Corporation is the most important among the Independents. Its capacity is the largest of any individual steel plant in the country. The company is one of unquestionable merit, but the preferred stock is selling at a fairly high price, all things considered. The stock is a seven per cent., non-accumulative preferred issue, and has paid nothing since 1907. The company has just sold $15,200,000 bonds,

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

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NEW YORK

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A Continually Growing Bank in a Continually Growing District

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ORIGINALLY sold for one-tenth cent an acre — recent sales at the rate of twenty-five million dollars an acre—such is the history of this wonderful Manhattan Island.

The marvelous growth of New York City and its suburbs, the remarkable increase in population (about 1,000 persons daily) with consequent enhancement of value are unprecedented in extent—unequaled in scope.

Billions of dollars are being made by realty experts and those associated with them. Perhaps you are one of the many who share these profits — if so, some of your money goes to make up the $10,000,000,000.00, now invested in New York Real Estate.

There is a medium through which you can keep informed regarding real estate and real estate securities.

We issue regularly a **Real Estate Market Letter** — an unusually interesting review of all important realty happenings in New York City and vicinity. Tells in a readable way, just the things which enable you to investigate before you invest—not afterwards. A reading of it should be to your decided advantage.

The mailing of the attached coupon entails no obligation on your part and will bring you, regularly, the Real Estate Market Letter.

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which represents a part of the total issue of $50,200,000 which is to be used for retiring outstanding obligations and additional working capital.

The report of the Hudson & Manhattan Railroad Company for the year ended March 31, 1912, shows gross earnings in 1912 of $4,845,491. The earnings for 1911 were $4,165,492, thus showing a gross increase of more than $600,000.

The consolidation of the B. F. Goodrich Company of Ohio and the B. F. Goodrich Company of New York was recently announced, with a capital of $45,000,000. The new company is organized under the laws of the State of New York for the purpose of dealing in rubber goods. The stock is divided into $15,000,000 preferred and $30,000,000 common.

Attorney-General Wickersham has taken action against the Federal Sugar Refining Company. The charges are underweighing and undervaluation of sugar imports.

The two motors for the collier *Jupiter,* now being built at the Mare Island Navy Yard at San Francisco, were tested at the General Electric Works on May 20 in the presence of United States Navy and shipbuilding officials.

The plan to propel vessels of large size with the big electrical motors is the work of W. L. R. Emmet, engineer in the lighting department of the General Electric Company.

A feature of the equipment is the simplicity of control, it being possible for the men on the bridge to check the speed, stop or start the vessels, or back the engines from the bridge, so that the whole operation can be performed by using a simple mechanism right at the hand of the man at the wheel.

The turbine engine, generator, and motors from the General Electric Works, Schenectady, will be shipped within two months.

The total sales of pig iron for April are estimated at 1,000,000 tons.

A substantial increase in car orders has been shown during the first four months of the present year. The figures for the four months are 70,400 cars, or at the annual rate of 211,500 cars, compared with 115,000 in 1911.

The steel manufacturers of Germany are much disturbed at the possible disruption of the price union. Disputes have arisen over the manner in which the business has been allotted, and it is feared that the quarrel will result in overthrowing the agreement as to prices and output.

Question—From whom can we secure reliable information regarding real estate investments and mortgages in New York?

Answer—We would suggest that you write to the Debenture Corporation of New York, No. 334 Fifth avenue, who have been highly successful in this line and on whom you can absolutely depend.

The United Shoe Machinery Corporation in the fiscal year just ended has broken all previous records for net earnings, but the percentage of increase has been disappointing. The total figures are $5,856,033, compared with $5,772,143 in the previous year. The percentage of increase is 1.4 per cent., which does not compare favourably with a previous increase of 2.3 per cent. and a 17 per cent. increase two years ago. The comparatively small net increase is due to the expense of additions to the Beverly plant and setting aside one-half million for leases and Government litigation.

The recent advance of several points in the common stock of the Underwood Typewriter Company has caused rumors that the stock is to be placed on a six per cent. basis this fall. The gross earnings of the company thus far this year show a large gain over last.

Subject to the approval of the Court of Appeals, a syndicate of bankers, headed by J. P. Morgan & Co., have underwritten the bond issue of the Interborough Rapid Transit Company, amounting to $170,000,000. The syndicate will get the bonds at 96.

The amount of money being expended within the city limits of New York for improved transportation facilities is tremendous, almost beyond the comprehension of man, and yet some people wonder why property values in New York continue to advance.

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Broadway and 72nd St.

New York City

OFFERS SUPERIOR ACCOMMODATIONS AT MODERATE RATES

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S. L. ROOT, MANAGER

Attractive Summer Rates

Pine Orchard, Connecticut

is situated directly on Long Island Sound, 84 miles from New York City and 12 miles from New Haven.

This attractive resort, where you would like to live this summer, offers nearly all that any one could desire in the way of out-door sports and amusements, with its fishing, bathing and boating, also country club with lawn tennis courts, clock golf and a "sporty" golf course, splendid macadamized roads for automobiling and driving.

I live there myself during six months of the year, besides spending many pleasant week-ends during the winter. At the suggestion of some of my neighbors this advertisement is inserted for the purpose of interesting a few more congenial people, in order that desirable tenants may be found to occupy the few cottages unrented.

If a shore-front house surrounded by grass, trees, woods and country seems to appeal to you perhaps you will want to know more about these roomy houses. Everything that makes housekeeping easy in the way of city water, gas, electric lights, telephones, baths and open fire places is there.

Pine Orchard is accessible—yet retired. The grocer, butcher, milkman, baker, iceman and newsboy, make daily deliveries, but the usual fuss and conventional restrictions of summer resort life are absent.

If this sounds "too good to be true" call and see or write for photographic proof and judge for yourself.

EUGENE E. ADAMS
334 Fifth Avenue
New York City

As soon as completed, Marburg Brothers, Inc., will move to their new suite of offices on the eighth floor of the U. S. Rubber building, at the corner of Fifty-eighth Street and Broadway, New York, N. Y. The Marburgs are agents in the United States and Canada for the MEA Magneto, SRO Ball Bearings, and Marburg-Hagen Springs.

Question—What do you think of buying mining stocks through curb houses on margin?

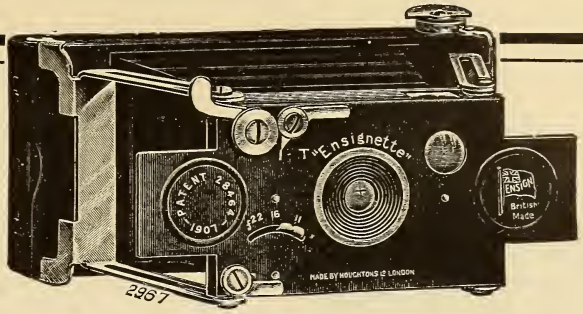
Answer—Don't buy mining stocks through any house on margin. Any broker that will recommend buying mining stocks on margin is open to question.

In a recent issue of its Real Estate News Letter the Debenture Corporation of New York states that there are 27,300 factories in New York City, which employ 669,000 people, and the output of the factories is valued at $2,249,000,000. It is also interesting to know that New York City has within its boundaries 1,565 miles of railway.

The monthly statement of the Department of Commerce and Labor shows the total value of exports for April to have been $176,000,000, against $154,900,000 for the same month last year. The imports were $162,700,000, against $119,800,000 for April, 1911. During the past ten months our exports have aggregated $1,865,300,000, which is an increase of $139,000,000 over the same period of last year.

Since May 1 rail orders have aggregated 366,000 tons, and contracts are now pending for 100,000 tons for domestic lines and 200,000 tons for export, the latter including 150,000 tons for Australia.

It is reported that since the 1st of May car contracts have aggregated 38,841, and it is estimated that more than 50,000 are practically within the market.



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Illustrated list on application. Camera sent prepaid on receipt of price. Money cheerfully refunded if unsatisfied.

24-26 E. 13th Street NEW YORK **G. GENNERT** **320 S. Wabash Avenue CHICAGO**

The Journal of Commerce and Commercial Bulletin recently reported the sale of the Brulay sugar plantation, located in the Rio Grande Valley, near Brownsville, to a wealthy New Yorker. The sale of this plantation is particularly interesting, as its former owner was the first to grow sugar cane in the Rio Grande Valley section of Texas on anything like an extensive scale. However, the industry he started has now developed to be one of the important industries of the United States, as the sugar cane industry of the Rio Grande Valley is one of the many highly profitable crops of that fertile section.

Modern Steamship Construction and Operation

This great story full of interesting features

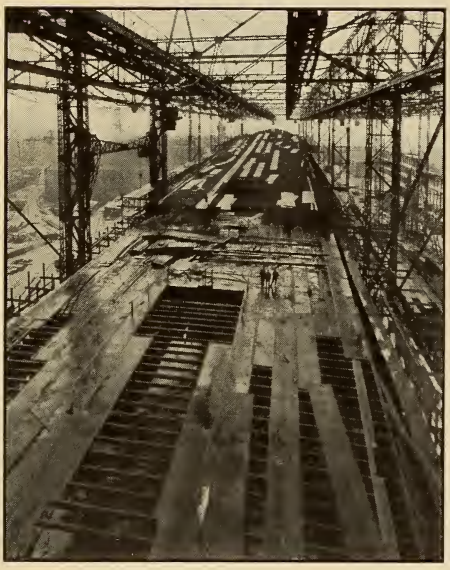
By THEODORE C. DEITRICH

will appear in CASSIER'S MAGAZINE for August. Don't Miss It.

READ CASSIER'S MAGAZINE FOR AUGUST

S. S. Imperator

(Concluded from page 63.)



CONSTRUCTION OF THE DECK OF THE S. S. "IMPERATOR"

The *Imperator* will carry a crew of 1,100 men. A large number of able seamen will be attached to the deck personnel. Her lifeboats are capable and seaworthy and enough of them will be provided to insure room for every passenger, including the entire crew. There will be a life-belt for every passenger aboard. There will also be a number of life-buoys, which will show a light upon coming in contact with the water. The ship will be equipped with steam fire-fighting apparatus of the latest and most approved type. Hand extinguishers will also be placed throughout the ship. A series of powerful pumps will always stand ready for immediate use. Among her special precautions against fire will be a number of smoke bulkheads on the passenger deck. The crew may be assembled by station bells and frequent drills will be carried on. It is believed that the safety of passengers on the *Imperator* is more completely assured than would be possible on ships of smaller dimensions.

-the safest pen for Field work is

The SECURITY Guaranteed Fountain Pen

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No. 3 S.Y. made with a short, heavy cap that screws down tightly over the section. 14kt. Gold Nib. Prevents any leak or overflow of ink while the pen is carried in vest or trouser pocket or traveling bag, or while lying flat on desk. They are the safest and most convenient pen made, and hold plenty of ink for ten days' use.

Sent postpaid for ten days' trial— money back if you want it. $1.50

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No. 33 This pen has a smooth point and patent needle, insuring a ready and easy flow of ink. Writes ten days without refilling. This Stylo Pen is made of the best quality pure Rubber in red or black and is manufactured in the best possible manner. This pen can be safely carried in the vest pocket or traveling bag, as it is an absolutely non-leakable Stylo Pen, and is always ready to write. "Buy a red one for red ink and a black one for black ink." $1.00 postpaid

DIAMOND POINT PEN CO., 39 to 47 West 19th St., New York

AN AUTOMOBILE AUDITOR

COST-KEEPING is growing more and more important each year. The age of *guess* is past; the age of *know* is here.

Efficiency in every detail is recognized as the real cause of success; lack of it, the reason for either limited success or even failure.

The trouble, however, which has been found with many systems of cost-keeping is their expense of operation—that the cost of ascertaining the cost, costs more than the amount that may be saved through the knowledge so gained. This is especially true when the cost of the cost-keeping system is both costly in itself and proves a continuous burden of expense.

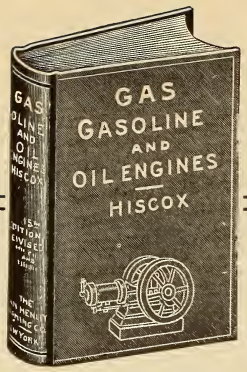
An ideal system of cost-keeping is one in which the first cost of installation is low, while the expense of its operation is greatly below the amount that may be saved through its use—one which proves a watch dog an unnecessary expense while affording a certainty of obtaining a maximum of efficiency at a minimum of expenditure, and a sure means of not only detecting errors and wastes, but, more important still, of preventing them and assuring proper service, both in performance of duty and amount of duty performed.

The more nearly automatic a cost system or device proves, the more useful and valuable it is, and when it combines absolute accuracy with wonderful simplicity, as is the case with the modern speedometer, for example, little is left to be desired and practically nothing to chance.

For the practical autoist, the man who wants his car to give him all the service he has paid for, the installation of a speedometer will go a long way toward enabling him to obtain his desire, and will be found to be an "automobile auditor," whose reports will tell him much in addition to the speed and distance traveled—will, in fact, add greatly to his pleasure, while proving a decided factor in lessening its cost.

The popular impression that a speedometer is used only for telling speed and distance traveled is far from correct. Every motorist fully appreciates such interesting information, and realizes that the speed indicator will often prevent running faster than traffic regulations make it wholesome to do, thus saving the expense and humiliation of being put under arrest by the lynx-eyed constabulary and having to pay a fine which may run as high as $200; still, many autoists do not seem to realize the other important services the speedometer, in conjunction with its odometer feature, renders and assures.

In the matter of backing claims for rebates on tires which many manufacturers guarantee to cover a certain number of miles, the "Automobile Auditor" will pay its cost many times over in a year. In the event that tires do not last the guaranteed mileage, a pro rata allowance is made on the next purchase, and as no car owner can *guess* the number of miles the tires have run, for a *guess* has often the result of making him pay full price for a new tire, while he had a substantial rebate coming to him had he but known it. A certain method of securing the benefit of such rebates is to record the date when the tire is put in use and the mileage recorded by the odometer at that date, then when the time comes to replace the tire an examination of the odometer will show one if they have covered as many miles as the guarantee calls for.



GAS, GASOLINE AND OIL ENGINES
By GARDNER D. HISCOX, M.E.
Just issued. Twentieth edition. The book treats on the theory of Gas, Gasoline and Oil Engines as designed and manufactured in the United States. Explosive motors, stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric Ignition by Induction Coil and Jump Sparks are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. 450 octavo pages, fully illustrated by 351 engravings. Price.....$2.50

MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT
By OSCAR E. PERRIGO, M.E.
A work of 400 pages, dealing with every problem connected with the building and conducting of a modern factory or shop. The subject-matter embraces the designing of the buildings, the installing of machinery, etc., and the turning out of work. For convenience the book is divided into three parts: The first part deals with the construction and the providing of power, heating and ventilating and lighting; the second part takes up the equipment, both mechanical and administrative, and the third part pertains to management, introducing a simple and efficient time and cost system. Price.....$5.00

HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL
By JOSEPH V. WOODWORTH
A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price.....$2.50

PATTERN MAKING
By F. W. BARROWS, Practical Pattern Maker
This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price.....$2.00

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By the same simple process the odometer will save money on the gasoline you burned, an item that amounts to no inconsiderable figure every month. The filling of your tank is generally left to others, and you have no means of knowing if you get the full amount of fuel you are paying for unless you check it up now and then with your odometer.

The odometer will also audit your engine efficiency by permitting you to keep it tuned to a point at which you get the maximum efficiency with a minimum fuel consumption. Test it now and then with an odometer, and make certain your engine consumes a quantity of gasoline proportionate to the number of miles the car has covered. The same instrument will audit your battery service and help you determine what make of battery gives you longest service.

Few realize how important a speedometer-odometer proves in touring, particularly in unknown territory—in fact, it is an absolute necessity. The road maps give the turns as so many miles, or parts of miles. From a given point the odometer tells you just when that mileage has been reached, thus removing all fear that you will turn down a wrong road. "Joy riding," too, is nearly an impossibility with a car supplied with a speedometer, as the first unauthorized use of the machine will show on the odometer.

It will thus be seen that the installation of a speedometer insures economy and safety, and not only keeps you posted on the number of miles traveled and the speed at which they are traveled, but also their cost to you, thus insuring economical service and greater satisfaction in the operation of your car.

It is not alone, however, in the certain and undisputable evidence which the use of a speedometer assures you when your car is in service and in the security it affords you that your car will not be used by others without your knowledge, but when the time comes to purchase a new car to replace the old, it will be found

to afford great aid in another most important thing—that is, in determining if the make of car gives you the service it should and if you are justified in purchasing another of the same kind.

Few realize to what extent speedometers are now used and the many applications for which they have been found most efficient, some few of which have been given above.

Many car manufacturers supply them as standard equipment, as part of the car, which means that the speedometers must be manufactured in tremendous quantities.

One of the largest, if not the largest, speedometer factory in the world is located in Chicago, manufacturing the Stewart Speedometer, which requires a factory occupying four acres of floor space and gives employment to over 500 persons, having an output of over 1,500 per day.

Service is an important factor in this branch of industry, as well as in all other lines, and a tremendous factor in the success of the Stewart Speedometer is the great care given by its makers to assure its being a reliable "auditor of the automobile"; and an indication that it has been so found is the fact that, to meet the demand for it, the Stewart Speedometer Company has eleven branches across the country from Boston to San Francisco. The use of a Stewart Speedometer has banished the factor of *guess* and installed the one of *know*, which is the true secret of efficiency.

On pages 86 and 87 of the May number of this magazine appeared an illustrated description of the Smith recording gas calorimeter, which has been found of such value in determining and recording the heat value of producer gas. Through error, the address of the Lexington Instrument Works, the manufacturers of this calorimeter, was given as Lexington, Ky., instead of Lexington, Ohio, where their establishment is located.

THINK OF IT

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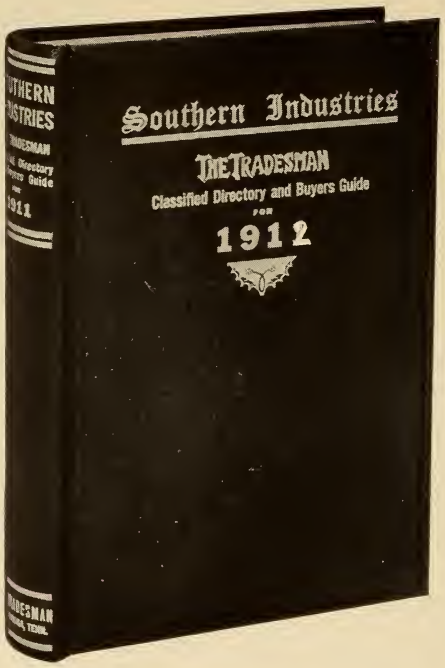


Ready for Delivery

SOUTHERN INDUSTRIES for 1912 has just been published. Several new features have been added, including a compilation of all the available statistical information about the South and Southwest, and a list of the Southern Commercial Clubs and officers.

About forty thousand names are included, covering fourteen states and thirty industries.

Only a limited number of copies are left. These will be sold for $5.00, including a year's subscription to The Tradesman. Send us your order now and pay for the book when you get it.

THE TRADESMAN,
Chattanooga, Tennessee

PORTABLE MOTIVE POWER FOR ROW BOATS

THE great advantage of a propelling device for row boats is appreciated more each year. Both for pleasure and practical work such devices are attracting much attention, and are largely used by hunters, fishermen, automobilists and pleasure seekers.

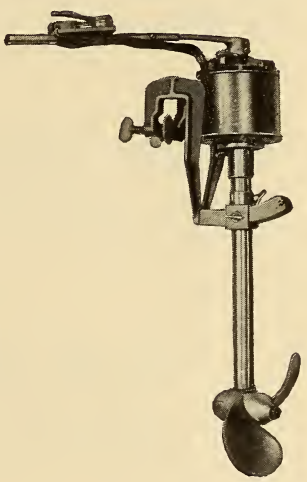
Such a device, to be of the greatest value, must be of such weight and size as to be easily portable, so that it can be pushed under the seat of an automobile, or placed in a suit case and transported with ease; in addition, it must be strong in construction, simple in design and operation, and easily attachable to any canoe or row boat.

A motor of this kind which is meeting with great success is the Jewell Row Boat Motor, which weighs, complete, only 25 pounds, and can be attached to a boat in a few minutes by anyone, and, as it is absolutely noiseless, it is greatly appreciated by fishermen and hunters.

This is the second season of the Jewell Row Boat Motor, and the practical necessity for such a device has been demonstrated. It is patented in the United States and all foreign countries, and its inventor has had ten years' practical experience in designing electric boat propelling devices and electric storage batteries.

This motor is in use by large lumber camps for practical work, on yachts for emergency when the wind fails, while many large boats use them on auxiliary skiffs; and this season it will be tested out by certain departments in the United States Navy.

The mechanical and electrical features of this row boat motor are described below:



JEWELL ROW BOAT MOTOR

The electrical motor is mounted vertically on a supporting tube, and has a maximum speed of twenty-five hundred revolutions per minute. Two six-volt, sixty-ampere-hour storage batteries connected in series supply current for the motor. The motor is direct connected to a vertical transmission shaft about 2 feet above the waterline.

The power is transmitted to a pair of special gears somewhat similar to the worm gear type. The circular gears operate in a gear housing below the waterline and change the vertical power transmission to the horizontal propeller shaft.

The lower gear housing and the two-blade weedless propeller are made of an alloy of aluminum, which reduces the weight of the motor so that it can be carried with ease packed in a suit case. The entire outfit is highly nickeled, and makes a very handsome appearance.

The electric motor shaft runs on

THINK TWICE

Once about

the Isolated Plant advertised on page 14 of this Magazine.

Once about

Cassier's Magazine in which you are reading this advertisement.

And then

realize that $2.60 will give you these two magazines for a whole year.

THINK ONCE MORE

The Isolated Plant - - $1.00
Cassier's Magazine - - 3.00 **$2.60**

Less than two-thirds of the regular price.

You surely can not let this chance slip by

The Isolated Plant
366 Fifth Ave.
New York
N. Y.

Hess bright ball bearings, and all other bearings are manganese bronze. The gear housing is watertight, so as to keep the gears operating in a bath of oil. Once the housing is filled with oil, it will be sufficient lubrication for six months' running.

The lower bearing of the motor is screwed into the vertical supporting tube and the motor shaft slips into a groove socket in such a manner that when the motor is unscrewed the entire machine can be taken apart in a few seconds and packed in a carrying case.

The row boat motor is used both as a propelling device and also as a rudder. The slightest change in the angle of the propeller changes the direction of the boat. Direction of boat is reversed by simply turning the entire motor on the swivel arm.

At the top of the electric motor is fitted the steering wheel, made of aluminum, and an adjustable handle is adjusted to this wheel in such a manner that its position can be changed in a moment by means of two thumb screws.

On top of the steering wheel is mounted the rotary switch. This switch is waterproof and has three speeds. The proper speed regulation is obtained by varying the field excitation. If a slower speed is desired, only one six-volt battery need be used.

For commercial uses, where large, heavy boats must be operated, a three horse-power motor can be used with a larger three-blade propeller.

Each detail of the mechanism is worked out in such a practical manner that the entire device is foolproof and the number of parts are reduced to a minimum. Every part of the motor is made from special machine jigs, and the best tool steel and manganese bronze are used. Great care is used in having all parts registered and accurately fitted, so that all parts are interchangeable.

The rapidly increasing business in the manufacture of electrical row boat motors, due to the great demand for them, has outgrown the present factory facilities of the Jewell Electric Company, at 1122 South Milwaukee avenue, Chicago, Ill., and they are making arrangements to build a large new factory at Ravenswood, Chicago, Ill., which, when completed, will be devoted entirely to the manufacture of row boat motors, their present factory being maintained by them for the manufacture of the Jewell Open Window Storage Battery.

The Production of Portland Cement in 1911

One hundred and eleven plants, representing about 70 per cent. of the Portland cement manufacturers in the United States, produced approximately 77,877,236 barrels in 1911, as compared with 76,549,951 barrels in 1910, which represents an increase of only 1.7 per cent., as compared with the increase of 17.7 per cent. that occurred in 1910 over 1909. The average factory price per barrel, not including packages, in 1910 was 89.1 cents, in 1911 it was 86.7 cents, a decrease of 2.4 cents per barrel, or 2.68 per cent. The total shipment in 1910 was 74,540,711 barrels and in 1911, 75,931,891 barrels, an increase of 1.9 per cent. The following districts showed decreases in production: Lehigh, Kentucky, Southern Indiana, and the Great Plains and Mountain States, while increases are shown in New York, Ohio, Western Pennsylvania, Michigan, Illinois, Northeastern and Northwestern India, Iowa, Missouri, the Southeastern and the Pacific Coast States. Slightly better prices were obtained in the Lehigh district, New York, and in the Pacific Coast; elsewhere, prices obtained were either about the same as for 1910 or slightly lower, the highest average price per barrel being obtained in the Pacific Coast and Washington—i. e., $1.407, and the lowest in the Lehigh district—i. e., .763 cent, which, however, was an increase of 3.4 cents over 1910 price.

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

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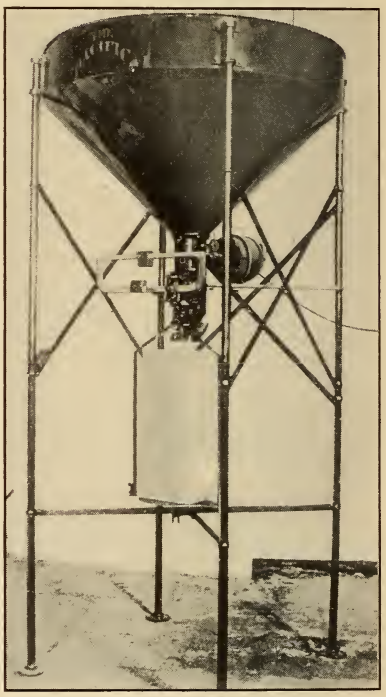
Motor Drive for Automatic Weighing Machines

SUGAR REFINERIES, wholesale groceries, canneries, candy factories, bakeries, etc., wherever large quantities of sugar are handled, have long felt the need of a practical weighing machine.

The Pacific Automatic Weighing Machine Company, of Oakland, Cal., is marketing an automatic sugar weigher with a novel motor application. The motor drives an agitator which stirs the sugar and insures an even flow and correct weight at all times by the prevention of lumping and clogging in the hopper.



AUTOMATIC SUGAR WEIGHER

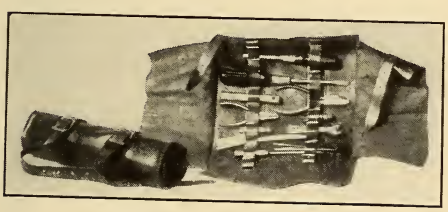
The operation of weighing out a large number of packages containing one, two, three or five pounds of sugar may be done in very much less time with the weighing machine than by the hand method.

Another advantage is the uniform weight. When the weighing beam is set at five pounds, for instance, the package is sure to contain exactly

that amount—no more, no less; while with hand weighing it is next to impossible to give exactly the same uniform weight.

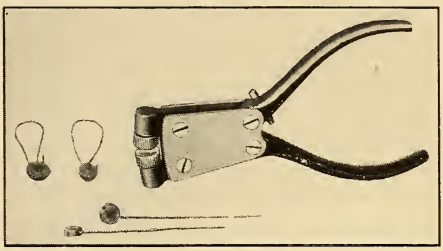
The motor is a 1/20 horse-power of Westinghouse make and applied directly to the weighing mechanism at the bottom of the hopper, and is connected to the agitator by means of a worm and gear. These motors have been extensively applied to machines of this character. They consume very little cement, and are exceedingly reliable in operation.

The motor control is effected entirely by the weighing beam. When the beam comes to a horizontal position, a switch is closed, which starts the motor; and when the required amount of sugar has passed from the receptacle the weighing beam drops to an inclined position, thereby stopping the flow of sugar, and at the same time opening the switch and stopping the motor.



WATT-HOUR METER REPAIR KIT

The watt-hour meter repair kit, illustrated above, is designed for the convenience of motor testers and repair men, and contains all the tools usually required for this work. The loops for holding the tools are adjustable, however, so that different tools may be added or substituted, as desired, to meet special conditions. The case is made of strong, pliable black leather, specially selected, with retaining flaps of the same material and two leather binding straps. The kit contains the following tools: One 4-inch screwdriver, one 2½-inch screwdriver, one 4-inch pin screwdriver, two No. 0 flat wrenches, one socket wrench, one pair 4-inch diagonal cutting pliers, one pair 3-inch flat, long-nose pliers, one pair 1-inch tweezers, one toothbrush, one pocket level and one bottle watch oil.



SEALING TOOL AND SEALS

The illustration shows a sealing tool and seals used for sealing watt-hour meters. The tool is 6 inches long, the maximum distance between handles 3½ inches, the weight 10 ounces, enabling it to be carried in the pocket without any inconvenience.

The jaws of the tool are fitted with removable dies, between which the seal is compressed. The removable feature of the dies enables one tool to be used for either plain or engraved sealing. A set screw in one handle permits the adjustment of the tool for a minimum closing distance of the jaws.

The seal consists of a small lead disc attached to two strands of wire twisted together. There are two holes in the disc, enabling the wire to be passed through it twice, thus making it impossible to withdraw the wire after the seal has been compressed by the tool.

These devices are manufactured by the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa.

Workmen's Compensation Laws

Workmen's compensation laws formed the principal subject for consideration at the annual meeting of the Manufacturers' Bureau of Indiana, Indianapolis, May 22 and 23. M. W. Mix, president of the

Bureau and head of the Dodge Manufacturing Company, devoted much of his annual address to a discussion of the subject.

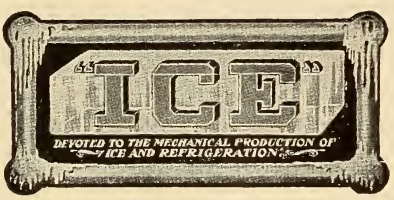
"With a development of the workmen's compensation idea, the abolishment of the three principal defenses in employer's liability cases," said Mr. Mix, "the need of education in these subjects will be more and more keenly felt by the smaller establishments, and more interest will necessarily be taken in a State organization. As such institutions will be the greatest proportionate sufferers through the passage of such laws, I believe we should start a campaign for that class of memberships, carrying, as it does, that much larger representation and co-operation in the members elected to the Legislature, thus securing a better opportunity for impressing such members with the inequities of many of the proposed laws."

Mr. Mix recounted the work of the legislative committee at the last session of the Legislature. He said that if any tangible benefit had accrued to those for whose benefit the employers' liability law was passed it has not been so demonstrated, with the possible exception that claims are more speedily settled, but not to any greater net cost to the liability insurance company.

Continuing, Mr. Mix said:

"A bill was introduced to provide for a system of workmen's compensation for injuries, but the Governor and others became convinced that such a bill would be declared unconstitutional, and the bill was not reported out of the committee. However, in his plan for a new Constitution, it is provided that such a bill may be passed, and I am firmly convinced that we will eventually have such an Act in Indiana as is now effective in Illinois, Wisconsin and a number of other prominent manufacturing States.

"The idea that the various industries should provide for the accidents



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and diseases due to their respective lines, the expense thereof to be considered as a part of the manufacturing cost, seems to be taking firm root in the minds of our people.

"All employers, large or small, should study the question thoroughly, and be prepared to discuss it with legislators and with their employees, to the end that precipitate, unfair measures be not passed.

"The effect of these laws on manufacturers who have local State compensation acts, and who must compete with manufacturers of other States where such acts are not in force, is very serious, and it will eventually lead to such laws being passed in all States. To anticipate this, all manufacturers should confer for the purpose of developing uniform laws in the various States and eliminating the unfair burdens that are likely to be imposed through lack of co-operation."

Doherty Patents on Gas Producers' Operation Upheld

The United States Circuit Court of Appeals for the First Circuit, hearing on appeal the case of the Combustion Utilities Corporation vs. the Worcester Gas Light Company, has rendered a decision fully sustaining the decision of the United States Circuit Court for the District of Massachusetts in favour of the complainant, the Combustion Utilities Corporation. This suit was to establish the validity of the patents of Henry L. Doherty covering an apparatus and process for controlling and regulating combustion in a gas producer. It grew out of the installation of gas benches for the Worcester Gas Light Company, which infringed the Doherty patents. The final decision upholds the Doherty patents in every way and, as demonstrating a distinct improvement in gas producers, it will be of interest to all concerned with the problems of cheap power and fuel economy. The evidence advanced in the trial of this case proved that the Doherty apparatus and process realized three things of vital importance to gas-producer plant operator—namely, a non-clinkering gas producer, a higher economy of fuel, and a positive control over the quality of the producer gas.

Water-power Resources of Penobscot River Basin of Maine

If a hundred men were to start out in search of undeveloped resources on which to realize opportunities and to develop industrial plants, it is probable that seventy of them would start West, twenty-nine would go South, and only one would turn to New England. The notion is prevalent that this older portion of the United States has been thoroughly canvassed and that the only way to achieve success there is to fill some dead man's shoes. Of course, this general impression is false. A careful study of the situation in New England develops the fact that, notwithstanding its comparatively long industrial history, the opportunities for development there are quite as attractive as the justly famed ones of the West or the less advertised but substantial opportunities of the South. New England industrial development is still in the making, and a belief to the contrary is the result of popular habits of thought.

A very good demonstration of the truth of the foregoing statement is furnished by a new publication of the United States Geological Survey, Water-Supply Paper 279, which is entitled "Water Resources of the Penobscot River Basin of Maine," prepared in co-operation with the Maine State Survey Commission. This paper contains the most complete information available concerning the general hydrographic features of the Penobscot basin, the rainfall, and the flow of streams, including floods and low waters. It also gives facts concerning the developed water-

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powers and the industries using them and sets forth in some detail the locations and capacities of the undeveloped water-power privileges.

The publication shows, for example, that the important water-power developments of the Penobscot basin, exclusive of numerous small gristmill and sawmill installations, aggregate a capacity of 66,190 horse-power.

Graduate Scholarships in Electrical Engineering at the Massachusetts Institute of Technology

The Committee on Graduate Scholarships has recommended scholarships for Messrs. R. D. Huxley, A. L. Matte, L. C. Tomlinson, E. L. Bray and H. E. Dexter, who are candidates for advanced degrees in Electrical Engineering at the Massachusetts Institute of Technology. Three of these young men are candidates for the degree of Doctor of Engineering. The popularity of the post-graduate study of Electrical Engineering at the Institute continues to increase. A number of Master's degrees in Electrical Engineering will be granted this year in addition to fifty or more Bachelor's degrees.

The following publications issued by the Geological Survey are available for distribution to those who have not received them:

A Preliminary Report on the Florida Phosphate Deposits. Reprinted from the Third Annual Report, pp. 17-41, 1910, 5 pls.

A Preliminary Report on the Peat Deposits of Florida. Reprinted from the Third Annual Report, pp. 197-375, 1910, 12 pls., 14 figs., 1 map.

Production of Phosphate Rock in Florida During 1910. 4 pages.

The reports of the Geological Survey are published by the State for distribution to citizens and to school and public libraries. They may be obtained free by addressing E. H. Sellards, the State Geologist, Tallahassee, Fla.

Graphite as a Surfacer

Lubrication is the very life of a moving mechanical part. If you neglect lubrication or do it on a hit-and-miss principle, you pay for it by broken parts, shutdowns and other kindred troubles. The road to the junk heap is made an easy one if insufficient or inferior lubricants are used.

No matter how well you may think a piece of machinery is lubricated, unless provision is made for the time when oil or grease fail to do their duty (caused by an obstructed oil channel, overload, leaks, etc.), very serious abrasion is likely to take place, and it is then the lubricant which can stand up under adverse conditions, take its knocks, and is not thin-skinned, that protects you against losses. Ticonderoga Flake Graphite is the only lubricant which will keep metal surfaces apart, because of its affinity for metal surfaces and its ability to knit up over them a covering, tough, thin and unctuous to the highest degree. In fact, it is this wonderful surfacing ability which makes flake graphite so valuable as a lubricant.

When this graphite surface is produced, it is surprising to note how much easier and freer a piece of machinery runs and its greatly increased power.

Prof. Goss strikes the keynote when he says: "The tests show that with no other lubrication than flake graphite the journal and brass may be run together for hours at a time, heating up to a high temperature, and this may be done repeatedly, and yet the rubbing surfaces of the bearings remain unscored. As a protection against abrasion of rubbing surfaces I know of nothing that can equal the record of flake graphite as herein disclosed."

The Joseph Dixon Crucible Company, Jersey City, N. J., will be very glad to send special pamphlets treating on any desired phase of lubrication to those interested.

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Recording Gauges

AS a matter of record, and one well worth recording, the fact that the Bristol Company reports that more than 25,000 Bristol Recording Pressure Gauges have been sold is recorded here.

Their new catalogue, No. 1000, a sixty-four page, 10½ × 8 inch, book, just off the press, has been received, and in it is given a partial list of users of Bristol Recording Gauges. This list takes up nine pages and consists of about 2,000 names, and reads like a Blue Book of leading manufacturing and industrial concerns, a large majority of the principal firms and companies throughout the country appearing therein.

The Bristol Recording Instruments represent the result of twenty-two years' experience in design, development and manufacture, and the Bristol Company now offers the most complete line of recording pressure and vacuum gauges that has ever been placed on the market.

This new catalogue, No. 1000, lists all Bristol's Recording Pressure and Vacuum Gauges except round form models 50, 52 and 56, model 52 being listed in their bulletin No. 144 and the other two in their bulletin No. 148.

Other new bulletins received from this company include:

Bulletin No. 132, 48 pages, 10½″ × 8″, on Bristol's Recording Ammeters.

Bulletin No. 144, 4 pages, 10½″ × 8″, on Bristol's Round Form Recording Pressure Gauges, Model 52.

Bulletin No. 148, 8 pages, 10½″ × 8″, on Bristol's Round Form Recording Pressure Gauges, Models 50 and 56.

Bulletin No. 166, 4 pages, 10½″ × 8″, on Bristol's Patent Automobile Time Recorder.

Steam Pumps

Ingersoll-Rand Company, 11 Broadway, New York City, N. Y. Bulletin Form 7004, 12 6 x 9 pages, descriptive of Cameron Steam Pumps. This pump has fewer working parts than any other steam pump made. The steam mechanism consists of four stout pieces only, none of them delicate, intricate or exposed to injury. The operation of this mechanism is such that, while under full pressure of steam, the suction pipe may be lifted out of the water and the pump allowed to run away or race as fast as steam will drive it, without danger of the piston striking the head or any injury to the pump. The advantage of this can scarcely be exaggerated, since, under most conditions, any pump is liable to have its supply of water cut off unexpectedly.

The steam valve movement works in line with the piston rod without the intervention of arms or levers. The pump can, therefore, be run without danger of breaking at a greater speed than any pump employing an outside valve movement. This pump cannot reverse until it has completed its full, honest stroke; it can also be taken completely apart without disconnecting any of the pipes.

Catalogue shows the different styles manufactured, and gives tables of sizes and capacities, together with price.

Damascus Bronze

"Products of the Damascus Bronze Company" is a book of twenty-five pages recently issued by the Damascus Bronze Company, of Pittsburg, Pa. It is well worth owning by all interested in bearings and wearing parts, such as locomotive wearing parts, rolling mill bearings, machinery castings, gas and stationary engine bearings, street car journal bearings, water or air cooled roll neck bearings, screw boxes, gears, etc.

The company will be glad to send a copy to those interested.

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